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Evaluation of Watershed and Riparian Treatments

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Evaluation of Watershed and Riparian Treatments

U.S. Forest Service
Southwestern Region

Final Report
September 1992

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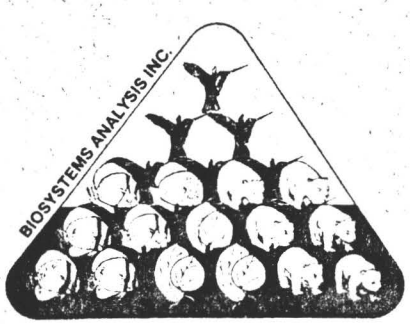

BIOSYSTEMS ANALYSIS, INC.

EVALUATION OF WATERSHED AND RIPARIAN TREATMENTS, U.S. FOREST SERVICE SOUTHWESTERN REGION

Submitted to:

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EXECUTIVE SUMMARY

Riparian areas are particularly important in the arid and semi-arid Southwest and concern for their protection, proper management, and maintenance is especially pronounced. The Southwestern Region of the U.S. Department of Agriculture Forest Service (USFS) has the primary responsibility for implementing stream improvements, riparian area restoration, and other watershed improvement projects in eleven national forests and grasslands in Arizona, New Mexico, and western Oklahoma and western Texas.

BioSystems Analysis, Inc., was contracted by the USFS to assess the primary causes of the success and/or failure of riparian improvement projects by reviewing existing information and conducting field inspections. A representative sample of 25 projects (29 sites) was evaluated using criteria developed for this study. Most of our evaluations were conducted prior to implementation of Integrated Resource Management (IRM) and none of the projects evaluated had the benefit of baseline information provided by completed Terrestrial Ecosystem Survey (TES) or Riparian Area Survey and Evaluation System (RASES). The site assessments are presented in this report as Appendix A.

Our evaluation stressed the importance of USFS participation and a multi-disciplinary qualitative assessment of selected evaluation projects. Our assessment focused on the entire process of selecting, planning, implementing, and maintaining treatments, including monitoring and evaluation. Project success or failure was evaluated by comparing each project with our model of an optimal project as defined by 14 evaluation criteria.

USFS projects succeed or fail for an array of single and interacting reasons. Factors influencing success and failure include technical, administrative, and personnel components. USFS practices that inhibit successful riparian area management include: a perspective that favors short-term temporary gains over long-term viable successes; emphasis on the quantity of projects rather than their quality; and too much reliance on in-stream structures without adequate problem identification, planning, interdisciplinary consultation, project design or maintenance. A sincere urgency in the desire to restore riparian areas may be responsible for a reactive posture that favors a "do-something" attitude.

Project documentation was consistently scarce, which made it difficult for us to determine the factors influencing success and failure and to learn from these experiences. Progress toward a better understanding of watershed and riparian area management has been frustrated by a consistent lack of monitoring and evaluation across the Region. Few riparian area projects are implemented in coordination with watershed management objectives.

Our most negative finding is that the Region has routinely failed to resolve la d use conflicts between grazing management and the desire to improve watershed d riparian area conditions. Poor grazing management is the most common obstacle to oject success.

1.0 INTRODUCTION

1.1 OBJECTIVES

BioSystems Analysis, Inc., was contracted by the U.S. Department of Agriculture Forest Service (USFS) to evaluate watershed and riparian treatments in the Southwestern Region under USFS jurisdiction and to present guidelines for the treatment of such areas in the future.

The overall objective of our study was to utilize the information available from past projects to develop these guidelines.

Our objective was achieved by completing the following activities:

1. Identification of the success or failure of structural and non-structural projects over a wide range of conditions at representative sites in the Southwestern Region.

2. Identification of the reasons for success or failure of activities relative to the project site and determine contributing influences.

3. Analysis and prioritization of the factors responsible for success or failure.

4. Refinement of recommendations based on the study findings.

5. Development of guidelines for designing restoration projects.

1.2 OVERVIEW

Riparian areas are particularly important in the arid and semi-arid Southwest and concern for their protection, proper management, recovery and maintenance is especially pronounced. The Southwestern Region of the USFS has the primary responsibility for implementing stream improvements, riparian restoration, and other watershed improvement projects in eleven national forests and grasslands in Arizona, New Mexico, western Oklahoma, and western Texas. For this study, the USFS Southwestern Region Watershed and Air Management staff reviewed a minimum of 125 possible projects. Of these, 25 projects encompassing 29 areas were selected to represent conditions in all 11 national forests (Figure 1-1). This report includes our evaluation of these sites based on criteria developed specifically for this purpose. The individual site assessments present a review of the entire process of selecting, applying, and maintaining treatments, including monitoring and evaluation. They are included at the end of the report as Appendix A.

The success of the projects undertaken by the USFS varied widely depending on the approach to planning, the resources available, and the expertise of the personnel

assigned to each project. Table 2-2 shows the average values for each site based on the criteria we developed for evaluating the restoration projects. According to this rating method, seven projects (24%) were good, 12 (41%) were fair, and ten (35%) were poor. While these are overall results, the table also reflects components which may have been consistently and successfully (or not) applied to each project. At a glance, it is possible to identify the Forests, the types of projects, and the criteria which need more attention.

Unfortunately, historical information which would be helpful for improving these complex and sensitive ecosystems (Figure 1-2) is not readily available and it is important to point out that land managers are responsible for implementing improvement projects with limited technical resources, a shortage of interdisciplinary expertise, and often with severe time constraints. In spite of these drawbacks, some projects were successfully implemented, either fully or in part. Many were unsuccessful. The projects were rated based on the key factors summarized at the end of each site assessment in Appendix A.

In general, the factors most likely to be responsible for their failure are as follows:

1. The Southwestern Region has routinely failed to resolve land-use conflicts.

2. Few riparian area projects are implemented in coordination with watershed management.

3. Monitoring and evaluation was conspicuously lacking from nearly all of the watershed and riparian projects.

4. Documentation was consistently lacking for all stages of a project.

5. Partnership concerns conflict with successful management.

6. Administrative and planning activities have a negative impact on riparian restoration projects.

7. The Southwestern Region typically has treated symptoms rather than problems.

8. Continuity in funding, treatments, management, monitoring, and maintenance is lacking.

9. Baseline inventories documenting potential and existing condition of riparian areas are inadequate.

10. True interdisciplinary approaches to riparian treatment are infrequent.

11. Few projects determine the range of project alternatives or define the possible consequences of action.

12. Project maintenance was almost completely overlooked in most cases and is a major cause of treatment failure.

These factors are analyzed in the body of the report.

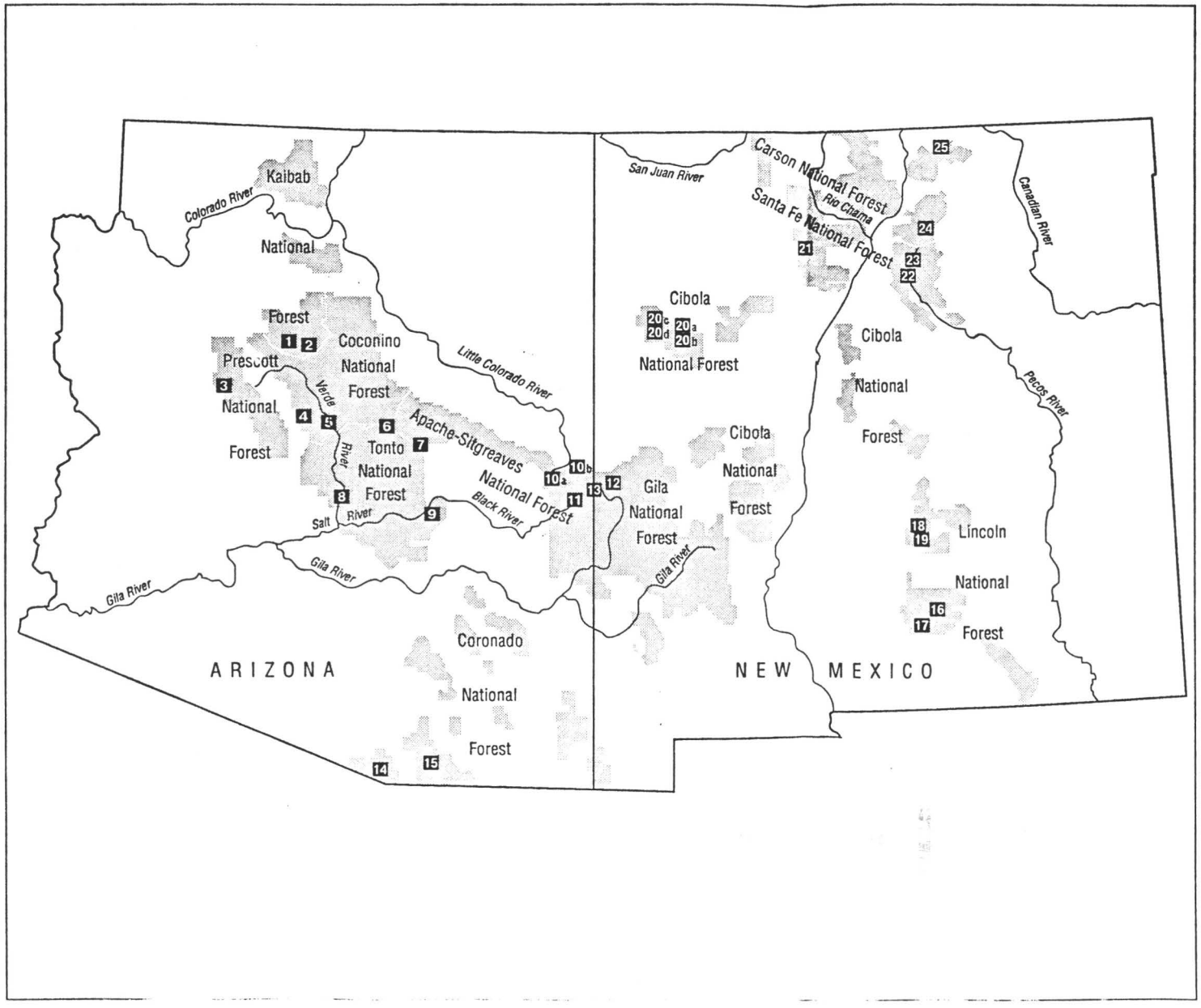

Figure 1-1. Location of 25 riparian/watershed treatments selected for evaluation.

LEGEND

1. Coleman Lake
2. Favor Tank
3. Cottonwood Canyon
4. Little Ash Creek
5. Verde River (Coconino National Forest)
6. Houston Draw
7. Canyon Creek
8. Verde River (Tonto National Forest)
9. Sedow Allotment
10a. West Fork Little Colorado River, above Sheeps Crossing
10b. West/East Fork Little Colorado River
11. Coyote Creek
12. Arroyo Grande
13. Romero Creek
14. Sycamore Canyon
15. Redrock Canyon
16. Aqua Chiquita
17. Sacramento River
18. South Fork Rio Bonito Creek
19. Main Rio Bonito Creek
20a. Bluewater Creek (revetments)
20b. Bluewater Creek (log structure)
20c. Camp Two Canyon
20d. Cabin Springs Meadow
21. Rio De Las Vacas
22. Holy Ghost Creek
23. Windsor Creek
24. Rio Pueblo
25. Comanche Creek

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NORTH

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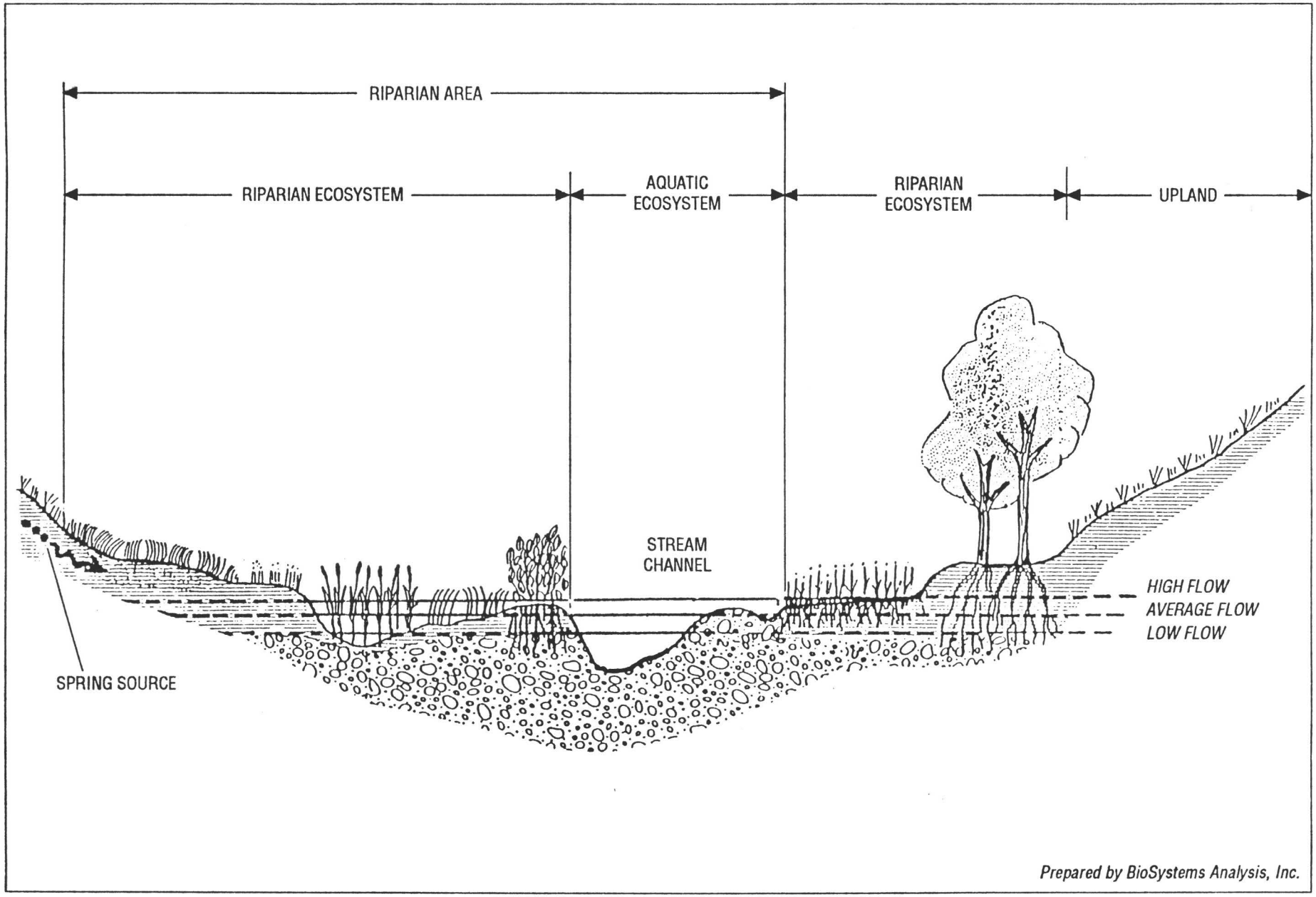

Figure 1-2. Schematic view of aquatic/riparian ecosystem.

Some aspects of some projects were successful and these are described fully in Section 3.2. There were evaluation criteria which were met successfully and consistently but these were limited to just one or two. Some projects were well-planned but not well implemented. Others were very well implemented but, as the cause of the problem had not been properly evaluated, they could not be called successful from an overall point of view.

The projects which demonstrated significant, successful elements were:

- Little Ash Creek
- Verde River (Coconino NF)
- West/East Fork Little Colorado River
- Sycamore Canyon
- Bluewater Creek (revetments)
- Cabin Springs Meadow
- Holy Ghost Creek

Two criteria were applied consistently across all of the projects and these were:

- Goals and objectives
- Funding

The cottonwood planting project along the Verde River is an example of a generally well-implemented project. The person responsible for it was enthusiastic and was given the time and resources necessary for the project to reach the appropriate standards. The project had a high profile (it arose as a result of threatened litigation), so line management was committed to its success. Had the project not been well implemented, public criticism and possible legal action against the USFS may have resulted.

The Cabin Springs project was also well implemented and construction was controlled. The motivation for the project was to improve watershed and wildlife resources. Expertise, commitment, pride, and having the time necessary to produce quality work were the keys to success.

The importance of commitment and motivation in successful implementation became apparent during the course of our study. Team members observed that several projects with inappropriate approaches and/or designs were nonetheless well constructed.

There were several instances where fences associated with riparian exclosures or pastures did not exclude livestock. This may have been caused by poor design and maintenance, as well as poor construction techniques.

Overall, the greatest improvements in project implementation could be achieved through an increased level of interest and commitment by line and senior staff and increased expertise (either through training or improved handbooks) by project personnel responsible for implementation.

2.0 METHODS

Members of the Southwestern Region Watershed and Air Management staff in Albuquerque, New Mexico, reviewed at least 125 possible projects for this study. Of these, 25 sites were selected to represent conditions in all eleven national forests in the Southwestern Region (Figure 1-1).

To achieve the project objectives, we stressed the importance of a multi-disciplinary qualitative assessment of treatments at selected evaluation sites. Our assessments focused on the entire process of selecting, applying, and maintaining treatments, including monitoring and evaluation.

The deputy regional forester sent a letter to the ranger in each participating district, briefly explaining the contract and requesting cooperation. We then telephoned the ranger or staff in each district to request information relevant to the selected projects. We were looking for documentation, past studies, personnel contacts, maps, and aerial photos. At the same time, we requested access to the site. A questionnaire was sent to each district to enable staff to evaluate their own projects. Once these were returned, the staff were contacted again to review and clarify the questionnaires and to make final arrangements for site evaluations. All evaluation sites were visited in either June or September 1990. At each site, team members met and interviewed the assigned district personnel.

Project success or failure was evaluated by comparing each project with our conceptual model of an optimal project. Our model simply consists of the fundamental components that form the basic framework for project planning, design, implementation and monitoring. These evaluation criteria or mileposts should be integrated into any watershed or riparian area project. We defined 14 primary project components that fit within this standard framework and used them as our evaluation criteria (Table 2.1).

Field data collection forms and a structure for conducting on-site interviews were developed. Our entire assessment process and our recommendations are based on the following criteria:

Evaluation Criteria

1. Problem Identified and Addressed: Was the reason or causative agent for the existing condition identified? Were project personnel able to discriminate between the symptom of the problem and the causative agent? Was the treatment directed at solving the root cause of the problem?

2. Goals and Objectives: Did project personnel set goals that allowed for future evaluation and monitoring? If goals and objectives were identified, were they sustainable?

Table 2.1 Watershed and riparian area treatment plan, indicating number evaluation criteria used in this study.

Preliminary Planning
1. Problem identified and addressed
2. Goals and objectives
3. Assess feasibility of approach
4. Conflicts with other values and land uses resolved
5. Interdisciplinary/Interagency coordination
Baseline Inventory
6. Characterize potential
7. Characterize existing conditions
Alternatives Evaluation
8. Evaluate alternatives
Project Design
9. Funding
10. Define evaluation criteria
11. Project action plan developed
Project Implementation/Inspection
12. Project implementation/inspection
Monitoring and Evaluation
13. Monitoring
Project Maintenance
14. Implement maintenance

3. Assess Feasibility of Approach: Was the selected approach feasible, given the land management goals and physical characteristics of the site? Was the problem-solving approach valid? If goals and objectives were not clearly stated, the team evaluated this criterion only on the basis of physical site limitations and treatment technology.

4. Conflicts with Other Values and Land Uses Resolved: Was the treatment compromised or the potential for success limited by other land management activities?

5. Interdisciplinary/Interagency Coordination: Was the level of coordination appropriate to ensure that all resource values were considered and integrated into the planning and design of the project?

6. Characterize Potential: Were the characteristics identified that influence the natural or attainable conditions (climate, geology and geomorphology)?

7. Characterize Existing Conditions: Were surveys, inventories, or studies conducted to obtain information on soils, hydrology, vegetation, habitat attributes, fish and wildlife populations, and related data?

8. Evaluate Alternatives: Were applicable alternative solutions evaluated? Were conflicting land uses considered in alternative evaluations?

9. Was Funding Adequate: Did funding meet planning, design, and implementation objectives?

10. Evaluation Criteria Defined: Were criteria established by which the success or failure of the treatment could be measured? Was the desired state of the site defined in measurable terms, e.g., canopy cover, bank stability, fish and wildlife populations, etc.?

11. Project Action Plan Developed: Was a plan prepared that clearly documented goals, objectives, and results of planning and inventory? Did the plan establish what was to be done (design, construction drawings, new Allotment Management Plans [AMP]), where it was to be done, by whom, and when? Was monitoring and maintenance included in the plan and was it budgeted?

12. Quality of Project Implementation/Inspection: Was the selected treatment implemented appropriately? Was there sufficient inspection and quality control to minimize unacceptable risks?

13. Monitoring: Was monitoring conducted and did it document success or failure and the reasons for success or failure? Were reasons identified for changing the project design?

14. Implement Maintenance: Was maintenance (planned or needed) performed to sustain the desired state?

Projects succeed or fail depending on the performance of the USFS at each of these steps. While some of our criteria are similar to those used in the National Environmental Policy Act (NEPA) process and the project implementation process of Integrated Resource Management (IRM) (USFS 1988), they are not the same. We believe a study should not be constrained by the structure of IRM, since IRM

incorporates public involvement processes, has explicit elements related to recording and documenting a decision, responds to program and budget considerations and to other regulations possibly affecting the overall decision-making process. However, all of the criteria we identified can be included within IRM.

Site evaluations were based on qualitative data. Sources of project data included questionnaires, background documentation provided by the USFS, verbal communications from phone and on-site interviews, and on-site observations by assessment team members. Very scant quantitative data was collected at project sites, as it was determined early in the study that gathering comparable data at all sites was outside the scope of this contract. A descriptive assessment of each project site is included in Appendix A. Differences in the degree of detail were influenced by the complexity of treatments, availability of project documentation, and the information gathered from interviews with USFS personnel.

Following synthesis and analysis of field and office data, we scored individual project site according to how well it met the evaluation criteria. We discussed each project to decide the extent to which the USFS had considered and incorporated each evaluation criteria. All team members participated in the ranking of treatment sites. The result is a matrix depicting ranking scores for project sites by evaluation criteria (Table 2.2).

Because appropriate, thorough consideration of each criterion would produce the best result, we used the criteria to evaluate the degree of success of each project. Following analysis of field and office data, we ranked each site. A site was good (score = 1) if the criteria were met satisfactorily; fair (score = 2) if there was an attempt to incorporate the evaluation criteria; and poor (score = 3) if there was no evidence that the criteria were earnestly considered. We used a "u" (no score) when it was impossible to determine whether or not the USFS had considered the evaluation criteria.

These evaluations are based on documentation provided by the USFS, interviews, and on-site inspections. Differences in the degree of detail were influenced by the complexity of treatments, availability of project documentation, and the information gathered from interviews with USFS personnel. A list of all wildlife, plant, and fish species is included as Appendix B.

The matrix was summarized by averaging scores and determining the percent frequency distribution of rankings across evaluation criteria to appraise the relative standing of evaluation projects (Table 2.2).

Color photographs were taken at each site to document treatments and management actions. Many sites were videotaped to further illustrate specific circumstances.

Key to Rating

1 = Good
2 = Fair
3 = Poor
u = Unknown or rating could not be determined

Evaluation Criteria

		Problem identified and addressed	Goals and objectives	Assess feasibility of approach	Conflict with other values and land uses resolved	Interdisciplinary/ Interagency coordination	Characterize potential	Characterize existing conditions	Evaluate alternatives	Funding	Define evaluation criteria	Project action plan developed	Project implementation/ inspection	Monitoring	Implement maintenance	
1	Coleman Lake	1	1	3	3	2	3	3	2	1	1	1	2	1	2	1.86 Fair
2	Favor Tank	2	1	2	2	u	2	2	u	1	1	1	1	2	3	1.67 Fair
3	Cottonwood Canyon	3	3	3	3	3	3	3	2	1	3	3	2	3	3	2.71 Poor
4	Little Ash Creek	1	1	2	2	1	1	1	u	1	1	1	1	2	1	1.23 Good
5	Verde River (Coconino NF)	1	1	1	1	1	2	2	1	1	1	1	1	u	u	1.17 Good
6	Houston Draw	1	1	1	2	2	2	2	2	2	2	2	3	2	3	1.93 Fair
7	Canyon Creek	2	1	1	3	1	3	1	3	1	2	2	2	2	1	1.79 Fair
8	Verde River (Tonto NF)	2	2	3	3	2	3	2	3	1	1	1	1	1	1	1.86 Fair
9	Sedow Allotment	1	1	1	2	1	1	2	2	1	3	2	3	3	3	1.86 Fair
10a	West Fork Little Colorado River, above Sheeps Crossing	3	u	u	2	u	3	2	3	u	3	3	3	3	3	2.80 Poor
10b	West/East Fork Little Colorado River	1	1	1	2	u	1	1	u	u	u	u	1	3	3	1.56 Good
11	Coyote Creek	2	3	3	3	2	2	1	3	3	3	3	3	3	3	2.64 Poor
12	Arroyo Grande	2	1	2	3	1	1	1	3	2	2	2	2	2	2	1.86 Fair
13	Romero Creek	1	2	3	3	2	3	2	3	2	3	2	2	3	2	2.36 Poor
14	Sycamore Canyon	1	1	1	1	1	u	2	1	u	1	u	u	2	1	1.20 Good
15	Redrock Canyon	3	3	3	3	2	3	3	3	1	3	3	3	3	3	2.79 Poor
16	Aqua Chiquita	2	2	2	3	1	2	2	3	1	3	3	2	3	1	2.14 Fair
17	Sacramento River	2	2	2	2	1	2	2	u	1	2	3	2	1	1	1.77 Fair
18	South Fork Rio Bonito Creek	3	3	3	1	u	3	3	3	2	3	3	u	u	u	2.70 Poor
19	Main Rio Bonito Creek	3	2	3	3	3	3	3	3	1	3	3	1	3	2	2.57 Poor
20a	Bluewater Creek (revetments)	1	1	2	3	1	1	1	1	1	3	1	1	3	1	1.50 Good
20b	Bluewater Creek (log structures)	1	1	2	1	1	2	2	2	1	3	3	1	3	u	1.77 Fair
20c	Camp Two Canyon	1	2	3	3	u	3	3	3	u	3	3	2	3	3	2.67 Poor
20d	Cabin Springs Meadow	1	1	1	2	2	1	1	1	1	2	1	1	2	u	1.31 Good
21	Rio de las Vacas	2	2	2	3	3	2	1	3	1	3	3	2	3	3	2.36 Poor
22	Holy Ghost Creek	1	1	1	1	1	2	1	2	1	3	3	1	3	1	1.57 Good
23	Windsor Creek	1	1	1	1	1	2	1	2	1	3	3	1	3	3	1.71 Fair
24	Rio Pueblo	2	1	1	3	2	3	2	2	1	3	3	2	3	u	2.15 Fair
25	Comanche Creek	3	3	3	3	3	3	3	3	2	3	3	3	3	3	2.93 Poor
		1.72 Fair	1.61 Good	2.00 Fair	2.31 Fair	1.67 Fair	2.21 Fair	1.90 Fair	2.36 Poor	1.28 Good	2.39 Poor	2.30 Fair	1.81 Fair	2.52 Poor	2.17 Fair	
	Good	14/48.28	16/57.14	10/35.71	6/20.69	12/50.00	6/21.43	10/34.48	4/16.00	19/76.00	6/21.43	7/25.93	11/40.74	3/11.11	8/33.33%	
	Fair	9/31.03	7/25.00	8/28.57	8/27.59	8/33.33	10/35.71	12/41.38	8/32.00	5/20.00	5/17.86	5/18.52	10/37.04	7/25.93	4/16.67%	
	Poor	6/20.69	5/17.86	10/35.71	15/51.72	4/16.67	12/42.86	7/24.14	13/52.00	3/4.00	17/60.71	15/55.55	6/22.22	17/62.96	12/50.00%	
	Total	29	28	28	29	24	28	29	25	25	28	27	27	27	24	

Table 2-2. Scoring matrix for watershed and riparian projects by evaluation criteria, U.S. Forest Service Southwestern Region.

3.0 PROBABLE CAUSES OF SUCCESS AND FAILURE

3.1 PROJECT EVALUATION

There are many interrelationships and dependencies among the evaluation criteria that we have used for this study (Table 2.1). The relative strength of these relationships, and the consequences of disregarding a particular step varies with the magnitude and type of treatment, and the ecological and political complexity of the project landscape. Generally, a successful project will have considered all the criteria at least once, and for many projects the process through these steps will be somewhat iterative. Therefore the order of our criteria should not be viewed as a strictly sequential process.

Several patterns were evident in the Southwestern Region's approach and its implementation of watershed and riparian treatment projects. Not surprisingly, similar patterns were observed between several criteria.

The USFS has paid greater attention over the past decade to the rehabilitation of watersheds and riparian areas under its jurisdiction. Successes and failures are as varied as the project locations and the surrounding habitat.

3.1.1 Problem Identified and Addressed (Evaluation Criterion 1)

Fourteen of the 29 (48%) projects we were able to evaluate for this criterion were rated "good" because they correctly identified and addressed the underlying problem. Fifteen (52%) projects were rated "fair" or "poor" because the causative agents were not discerned or addressed.

Projects where resource problems were identified included Coleman Lake, Little Ash Creek, Verde River (Coconino NF), Houston Draw, Sedow Allotment, West/East Fork Little Colorado River, Romero Creek, Sycamore Canyon, Bluewater Creek (revetments), Bluewater Creek (log structures), Camp Two Canyon, Cabin Springs Meadow, Holy Ghost Creek and Windsor Creek (Table 2.2).

3.1.2 Goals and Objectives (Evaluation Criterion 2)

Sixteen of the 28 (57%) projects we were able to evaluate for this criterion were rated "good" because goals and objectives were explicitly defined. Five (18%) projects were rated "poor" because they were carried out without defining goals and objectives.

Evaluation projects with stated and documented goals and objectives were Coleman Lake, Favor Tank, Little Ash Creek, Verde River (Coconino NF), Houston Draw, Canyon Creek, Sedow Allotment, West/East Fork Little Colorado River, Arroyo Grande,

Sycamore Canyon, Bluewater Creek (revetments), Bluewater Creek (log structures), Cabin Springs Meadow, Holy Ghost Creek, Windson Creek, and Rio Pueblo (Table 2.2).

3.1.3 Assess Feasibility of Approach (Evaluation Criterion 3)

It was difficult to assess this evaluation criterion because of the extremely poor documentation for many sites. However, ten of the 28 (36%) projects evaluated for this criterion received "good" ratings because they had feasible approaches. Eight (28%) projects were rated "fair" and 10 (36%) were rated "poor."

Projects with feasible approaches included the Verde River (Coconino NF), Houston Draw, Canyon Creek, Sedow Allotment, West/East Fork Little Colorado River, Sycamore Canyon, Cabin Springs Meadow, Holy Ghost Creek, Windsor Creek and Rio Pueblo (Table 2.2).

3.1.4 Conflicts With Other Values and Land Uses Resolved (Evaluation Criterion 4)

Only 6 of 29 (21%) projects were rated "good" because they included adequate analysis and resolution of this evaluation criterion. These projects were the Verde River (Coconino NF), Sycamore Canyon, South Fork Rio Bonito Creek, Bluewater Creek (log structures), Holy Ghost Creek, and Windsor Creek (Table 2.2).

3.1.5 Interdisciplinary/Interagency Coordination (Evaluation Criterion 5)

Twelve of the 24 (50%) projects evaluated for this criterion were given a "good" rating for interdisciplinary/interagency coordination. The four projects evaluated as "poor" (16%) seemed to be controlled by personnel who were extremely confident of their approach and were not willing to accept outside advice or interference. This attitude typically was isolated; however, the relevant projects were not initiated with the long-term viability of riparian areas in mind but, instead, for some special interest.

Little Ash Creek, Verde River (Cococino NF), Canyon Creek, Sedow Allotment, Arroyo Grande, Sycamore Canyon, Agua Chiquita, Sacramento River, Bluewater Creek (revetments), Bluewater Creek (log structures), Holy Ghost Creek and Windsor Creek demonstrated appropriate interdisciplinary/interagency coordination (Table 2.2).

3.1.6 Characterize Potential (Evaluation Criterion 6)

Twelve of the 28 (43%) projects for which we could evaluate this criterion were rated "poor" because there was no attempt to assess the site potential. Ten (36%) projects were rated as "fair" because some kind of assessment had been made. The remaining six (21%) projects addressed this important quest adequately. The six projects were Little

Ash Creek, Sedow Allotment, West/East Fork Little Colorado River, Arroyo Grande, Bluewater Creek (revetments) and Cabin Springs Meadow (Table 2.2).

3.1.7 Characterize Existing Condition (Evaluation Criterion 7)

Existing conditions were adequately characterized in 10 of the 29 (34%) projects. Twelve (41%) were rated as "fair" and seven (24%) were rated as "poor."

Little Ash Creek, Canyon Creek, West/East Fork Little Colorado River, Coyote Creek, Arroyo Grande, Bluewater Creek (revetments), Cabin Springs Meadow, Rio de las Vacas, Holy Ghost Creek, and Windsor Creek received "good" scores (Table 2.2). The best example of an appropriate characterization of existing conditions is the Rio de las Vacas project. However, even at this relatively well-studied and researched site, the lack of specific pre-treatment data on existing conditions was a factor precluding thorough assessment and interpretation of the effects of livestock grazing on this riparian area.

3.1.8 Evaluate Alternatives (Evaluation Criterion 8)

The projects with a "good" rating in this category were generally more recent and the IRM process had been explicitly followed; however, across the Region, this category was weak with an average rating of 2.4. Only 4 of 26 projects (15%) evaluated for this criterion were rated as "good." Only one other category, monitoring (Evaluation Criterion 13), had a lower overall rating. The rating reflects the generally disappointing level of documentation and is an indication that few of these projects received an environmental analysis consistent with NEPA.

A good example of alternatives analysis is the change in livestock management practices in the Cottonwood Basin Allotment along the Verde River in the Coconino National Forest. The scoping and decision documents reveal a through record of alternatives development and analysis. Interdisciplinary and interagency input provided a well-balanced assessment and evaluation. The Sycamore Canyon Resource Management Area (RMA) in the Coronado National Forest also is another good example of alternatives analysis.

3.1.9 Funding (Evaluation Criterion 9)

In general, riparian projects were adequately funded. Nineteen of the 25 (76%) projects evaluated for this criterion received a "good" rating because they had enough money to implement an acceptable project. As riparian issues have gained attention and have increased in importance, more funding has become available. Unfortunately, funds tend to have been allocated for project initiation and implementation rather than long-term commitment to monitoring and maintenance, which would help guarantee their success.

The quantity of projects has been emphasized over quality. Funding for mor oring and maintenance has generally been overlooked.

3.1.10 Define Evaluation Criteria (Evaluation Criterion 10)

Evaluation criteria for use in a monitoring plan were defined and documented only in very few projects. Only 21 percent of the projects (6 of 28 sites) evaluated for this criterion adequately incorporated this category into their riparian area management program. Even fewer projects followed through with any actual monitoring.

3.1.11 Project Action Plan Developed (Evaluation Criterion 11)

Of the 26 (27%) projects for which we were able to evaluate this criterion, only seven adequately developed a project action plan. Fifteen (58%) projects appeared to be executed without any written action plan and so were rated "poor."

The Coleman Lake wet meadow rehabilitation and enhancement project in the Kaibab National Forest included a reasonable project action plan; however, it did not provide complete information on hydrographic attributes or revegetation design.

The Bluewater Creek (revetments) project in the Cibola National Forest had a thorough project action plan. Bluewater Creek is a relatively extensive project and is somewhat of a showcase. In terms of developing an action plan, Bluewater Creek affords a good example for other projects to follow.

Projects rated as "good" included Coleman Lake, Favor Tank, Little Ash Creek, Verde River (Coconinio NF), Verde River (Tonto NF), Bluewater Creek (revetments) and Cabin Springs Meadow (Table 2.2).

3.1.12 Project Implementation/Inspection (Evaluation Criterion 12)

Across the Region, many projects were well implemented and inspected. Twenty-one of 27 (78%) projects we were able to evaluate for this criterion received a "good" or "fair" rating. Why some projects were implemented well and others were not is difficult to assess. The interest, commitment (pride in a job well-done), and the expertise of the people responsible are probably the most important factors in the quality of on-the-ground implementation. Rigorous design, the interest and commitment of senior staff and line officers, an appropriate level of staffing to enable project personnel to devote the time needed for quality implementation, and a high level of control over the personnel performing the actual construction all enhance the likelihood of a project's success.

More than a few projects which utilized an inappropriate approach or design were nonetheless well constructed and demonstrated the importance of commitment and motivation to a good end result.

There were many instances where fences associated with riparian enclosures or pastures were not excluding livestock; however, this may have been due to poor design and maintenance as well as poor construction techniques.

The cottonwood planting project along the Verde River (Tonto NF) is an example of a well-implemented project. The individual responsible for implementation was enthusiastic about the project and was given the time and resources necessary to implement it in a quality manner. The project had a high profile (as a result of threatened litigation) and the staff was committed to the project. Shoddy implementation had the potential to result in public criticism of the Forest Service.

The Cabin Springs project was also well implemented and construction was controlled. The motivation for the project was to improve watershed and wildlife resources. Expertise, commitment, pride, and the time necessary for quality implementation were the keys to success.

3.1.13 Monitoring (Evaluation Criterion 13)

Only 3 of the 26 (11%) projects evaluated for this criterion received a "good" rating because they adequately defined and documented monitoring plans. These projects were Coleman Lake, Verde River (Tonto NF) and Sacramento River. Seventeen (65%) sites were rated "poor" because monitoring was conducted. Basic monitoring and project evaluation was consistently ignored across the Southwestern Region. Monitoring, as a component of a successful project, was overlooked more often than any other evaluation criterion.

3.1.14 Implement Maintenance (Evaluation Criterion 14)

Most projects failed to include proper maintenance. Only eight of the 24 (33%) sites we were able to evaluate for this criterion were rated as "good." Twelve (50%) projects were rated as "poor" because they failed to incorporate reasonable maintenance measures.

3.2 SUCCESSES

An evaluation of the site assessments (see Appendix A) reveals that some aspects of some projects were successful. These were:

Site #2: Favor Tank

1. Planning and design were good.
2. Monitoring was adequate.
3. Revegetation program is succeeding.

Site #4: Little Ash Creek (Cottonwood Thinning)

1. Research problem identified and addressed.
2. Goals and objectives clearly stated.
3. Measurable evaluation criteria defined.

Site #4: Little Ash Creek (AMP)

1. Recognizes interdisciplinary approach.
2. Specific goals, objectives, and management actions stated.
3. Recognizes merits of monitoring and outlines a program to track the AMP.

Site #5: Verde River

1. Step-by-step documentation available.
2. Realistic goals, objectives, and evaluation criteria clearly stated.
3. Project integrated with natural terrain features and multiple resource uses.
4. Interagency project planning and analysis of alternatives.
5. Watershed and riparian issues addressed.
6. Project design incorporates acceptable maintenance and monitoring procedures.

Site #6: Houston Draw

1. Poor watershed conditions have been eliminated.
2. Current upland conditions are fair to good.
3. Structures are small but constructed of relatively large logs.
4. The approach to stabilization is headwaters to downstream.
5. Banks are cohesive.
6. Floods can spread over the meadow, at least in the upper reaches, limiting the force on the log structures.

Site #7: Canyon Creek

1. A goal for the management of Canyon Creek was clearly established.
2. Managers and specialists determined project objectives.
3. The USFS has so far made the necessary changes in land management to achieve the goal.
4. Habitat surveys were conducted in a systematic manner to compare the current condition with the optimum condition.
5. Monitoring is continuing.

Site #8: Verde River (Tonto National Forest)

1. Insightful Forest Service employees (i.e., D.A. Pollock).
2. Very good project analysis of impacts.
3. Funding for site development was adequate.
4. Evaluation criteria were defined for planting sites.

Site #9: Sedow Allotment

1. Riparian areas were placed under rest-rotation grazing with reduced utilization, instead of historic season-long continuous strategy and were grazed for no more than three months of each year.
2. Spring water supply distributed animals throughout the allotment and reduced grazing pressure on riparian areas.
3. USFS personnel were keen to work with the permittee to achieve a better management strategy.
4. An outside entity forced the USFS to move into better management. Once the problem was acknowledged, the willingness of USFS to take action achieved good results.

Site #10B: West/East Fork Little Colorado River

1. Structures are appropriate for the stream.
2. Deflector logs extend above the upper banks and direct flood flows away from ends of structures.
3. Banks are stable with a high rock content.
4. The channel substrate was the right size and approximated the bank material composition.
5. The low to moderate profile minimizes exposure to the force of the flood.
6. Large logs and rocks were used in construction.

Site #12: Arroyo Grande

1. Integrated planning to incorporate the development of wildlife habitat in the second dam.
2. Commitment to pursue watershed improvements aggressively.
3. Establishing and maintaining the watershed improvement needs inventory and continuing to use recommended measures.

Site #13: Romero Creek

1. Well-constructed and maintained structures.
2. Proper spacing and location.
3. Material dimensions proper, given exposure to flow and flow rates.

Site #14: Sycamore Canyon

1. Grazing strategy has been changed.
2. The exclosure fence has been maintained and there is no evidence of stock trespass.

Site #16: Agua Chiquita

1. Interdisciplinary expertise was applied.
2. Adequate funding was available.

3. Fences and structures have been maintained.

Sites #20A and 20B: Bluewater Creek Revetments and Log Structures

1. The project was well documented.
2. Goals and objectives were stated.
3. Conflicts with other land uses were resolved.
4. Structures were well constructed.
5. Interdisciplinary expertise was considered.

Site #20D: Cabin Springs Meadow

1. The problem (i.e., channel incision) was identified and addressed.
2. Goals and objectives were clearly stated and feasible in light of existing conditions and site potential.
3. The treatment was appropriate for achieving goals and objectives in the site.
4. Adequate funding was provided.
5. A project action plan was developed.
6. Structures were very well constructed.
7. Monitoring is anticipated.

Site #22: Holy Ghost Creek

1. Conflicts with other land uses were resolved.
2. Structures have been maintained.

Site #23: Windsor Creek

1. Conflicts with other land uses were resolved.

Site #24: Rio Pueblo

1. Project goals and objectives are clearly stated and approach is feasible.
2. Funding available for many structural and non-structural habitat improvements.

3.3 FAILURE

3.2.1 The Southwestern Region has Routinely Failed to Resolve Land-Use Conflicts Between Grazing Management and the Desire to Improve Watershed and Riparian Area Conditions. Poor Grazing Management is the Most Common Obstacle to Project Success.

The motivation for most treatments was poor riparian conditions, but the project team found that the root cause of these conditions was rarely addressed or resolved. The single largest factor limiting the success of treatments is the failure to rigorously design and implement a grazing strategy that would allow for sustained restoration of riparian areas. The symptoms of poor riparian conditions are treated rather than instituting the

type of management that will allow these areas to heal themselves through improved watershed and riparian area condition. As a result, the Region has tended to implement high-risk structural approaches or construct "postage-stamp" temporary exclosures that may lead to further degradation. In several cases, it appeared to our team that riparian treatments were constructed only to placate frustrated wildlife and watershed specialists where the root cause of the problem, improper grazing management, failed to be addressed.

3.2.2 Few Riparian Area Projects are Evaluated in Coordination with Watershed Management

Evaluation of alternatives is essential to resolving land use conflicts and characterizing the potential of a site. In far too many cases, the USFS did not develop a full range of alternatives because of an apparent unwillingness to resolve a conflicting land use (most commonly the current grazing strategy). This failure prevented development and evaluation of some of the most straightforward and effective treatments available, such as a change in grazing management. As a result, project personnel were invariably led to alternatives that tended to treat the symptoms of the problem, rather than the problem itself.

The lack of coordination can be viewed as a failure of management. Many projects were doomed to failure or resulted in a waste of funds because of a lack of commitment by senior staff and management in coming to grips with the cause of riparian degradation. Including "changes in management" as an alternative in project implementation appears to be the most difficult problem facing the USFS in successfully improving the condition of riparian areas. Certainly it is one of the most difficult situations facing line officers. Furthermore, Forest Plans have not fully resolved these issues. The process of developing and evaluating changes in management must be flexible if riparian areas are to be improved. While the Forest Plans can be amended, the amendment process is generally time-consuming and interferes with the capacity to be flexible.

Failure to evaluate changes in management also largely forecloses using watershed condition improvement as a mechanism to improve riparian area condition. In many cases, good watershed management can bring about the conditions which "set the stage" for resilient riparian areas to quickly heal themselves. In contrast, poor watershed conditions give rise to increased frequency and volume of peak flows, making it much more difficult for in-channel treatments to succeed.

The staff that originates a project seems reticent to aggressively pursue developing and forwarding "changes in management" as an alternative. Certainly, pursuing a structural or temporary-exclosure approach can be much easier to implement and represents a politically palatable and relatively "painless" approach to staff assigned to meet riparian improvement targets and objectives.

Another major contributor to the failure to properly evaluate alternatives is the lack of expertise of project personnel. Failure to fully evaluate alternatives frequently was preceded by a failure to accurately assess the potential of a site. In these instances, project planners failed to identify the conditions that must be present to make a particular alternative succeed. In several instances, cross-channel structures were installed in streams with banks composed of erodible material, resulting in erosion around the ends of the structure. Had the project planners had sufficient expertise in stream channel/riparian dynamics, they would have recognized that this type of treatment was inappropriate in such a setting.

High levels of expertise are frequently needed for riparian projects and management must demand excellence in project performance. This, in turn, should lead to actions which will ensure that levels of expertise are raised (through training and certification programs), that the Agency utilize the expertise it already has, and that guidelines be developed to ensure only qualified personnel are assigned to riparian projects.

3.2.3 Monitoring was Conspicuously Lacking from Nearly All Watershed and Riparian Projects.

Monitoring evaluates progress toward meeting management goals and objectives and determines maintenance needs. Monitoring is an important feedback mechanism. The lack of adequate monitoring and documentation has reduced the number of successes by limiting the transfer of technology and allowing mistakes to be replicated. At the same time, successful projects cannot be exploited and duplicated. Adequate monitoring, like any other component of a watershed and riparian treatment project, requires a commitment of time and money. In the case of monitoring, this obligation needs to be long term, bridge the gaps caused by personnel transfers, and prevail over specific short-term administrative and planning targets.

Only 2 of 26 (8%) sites where monitoring was implemented achieved a good rating (Table 2.2). Conversely, no monitoring was conducted at 18 (69%) of the sites. **Basic monitoring was consistently ignored across the Southwestern Region.**

Two sites, the Verde River and Little Ash Creek (Figure 1-1), were rated good for monitoring. The Verde River site in the Coconino National Forest provides an excellent contrast between new and old procedures used for addressing watershed and riparian treatments. Grazing practices had impacted the riparian communities of the Verde River and adjacent springs as well as their watersheds. Work conducted in the late 1970s and early 1980s did not include monitoring and documentation, photo-points, quantitative sampling data, or aerial photos, etc. In the more recent work, the District used the IRM project implementation process to address watershed and riparian concerns. Documentation of the decision process and the new AMP recognizes that riparian areas have been impacted by long-duration grazing and that these areas need to be enhanced

by exclusion or short-duration use. The goals and objectives are to protect and enhance riparian conditions. Riparian values identified in the AMP include vegetation age class and species diversity, water quality, and protection of aquatic habitat.

The AMP specified performance criteria and a strategy for monitoring the progress of riparian recovery. A team approach, consisting of range, wildlife, and watershed personnel, was used to monitor and evaluate the condition of the resources in Cottonwood Basin. This team provided input into the decision-making process for management of this area. Evaluation criteria and standards for riparian/watershed conditions include:

1. Number of days livestock use the riparian area.

2. Acres of woody vegetation in three age classes.

3. Observer evaluation and narrative on bank stability, herbaceous bank cover, and depth to width ratio.

4. Photo-points and transects taken before and after grazing and at various times during the year.

5. Percent utilization of terminal buds on woody riparian species will not exceed 10 percent.

6. A landscape description for Cottonwood Spring, Sycamore Creek, and Mesquite Spring riparian areas is determined as: "A series of small pools and/or a narrow stream channel with flowing water. The areas will have an increased density of watercress along with three age classes of willows and cottonwood species."

7. Photo-points will show an increase in the perennial grass community within upland areas.

The other example, Little Ash Creek in the Prescott National Forest, is a research level project, investigating growth and survival of young cottonwood trees. The study began in 1986 when treatment plots were established and trees were inventoried and then thinned. The response of individually tagged and cataloged trees was assessed each year by measuring depth at breast height and survival and, less frequently, by measuring canopy height. As might be expected with a research project, monitoring and documentation was adequate.

Photo-points were available for Sycamore Canyon depicting the changes that have occurred since livestock were excluded from the riparian area. However, there was no process or schedule established to periodically update or reevaluate photographs.

3.2.4 Documentation was Deficient or Consistently Lacking for All Stages of a Project. Good Record-Keeping is Essential to Successful Projects.

Another major cause of the failure of these projects is the lack of documentation. The implications of this deficiency are far-reaching. On a general level, maintaining an

accurate record of every stage of a restoration project enables USFS personnel to uphold their assertions of improved treatment and maintenance at specific sites.

Documentation such as photo points, quantitative sampling data, and aerial photos facilitate accurate evaluation of existing conditions and enable the development of an appropriate AMP. Where records have not been kept, the value of the completed work was undermined. Work conducted without an appropriate context was often made futile. For example, in Site 10A on the west fork of the Little Colorado River above Sheep's Crossing, the project failed because there was no information to make planning possible. Without any planning, it was impossible to develop an appropriate response to the existing conditions.

3.2.5 True Interdisciplinary Approaches to Riparian Projects are Infrequent.

Where appropriate, outside expertise should be brought in to complement the expertise of USFS personnel. At the Coleman Lake treatment site, it would have been helpful to have discussed the needs of the waterfowl population with a waterfowl habitat specialist, particularly when the principal goal of the treatment was to increase the population of these birds.

3.2.6 Public and Special Interest Group Involvement in Watershed and Riparian Area Programs has Many Benefits, but Partnership Concerns can Conflict with Successful Management. Partnerships are Increasing in the Region and Provide Valuable Expertise and Labor.

A further possible cause of failure may be pressure within the agency to cultivate partnerships with special interest groups such as Trout Unlimited. Such partnerships often result in a desire to "do something" structural in the stream or riparian area that can take advantage of a volunteer work force. Succumbing to such pressure tends to preclude fully evaluating management-related treatments that tend to provide more long-lasting sustainable improvements in riparian area condition.

3.2.7 Several Administrative and Planning Activities Have an Overall Negative Effect on Riparian Programs.

The difficulties with managing projects at an administrative and planning level over a period of time are historical. Projects are implemented by staff who are encouraged to transfer from regions regularly. High staff turnover precludes any meaningful level of personal commitment to projects. Provision for future monitoring is rarely made. The lack of documentation makes it difficult for new staff to become familiarized with projects.

Not surprisingly, with these inherent organizational difficulties, the Regions appear to be more inclined to support new projects than maintain existing ones.

3.2.8 In Many Cases, the Southwest Region has Relied on Instream Structural Solutions to Riparian Area Restoration. Typically, Structural Treatments Address the Symptoms of a Problem Rather than its Causes.

In Romero Creek (Site #13), while the structures were well-constructed and maintained, they have failed to improve fish habitat. The structure type and design are not well-suited to the stream type yet no other alternatives were explored. Had fisheries specialists been consulted about many of these projects, the root causes are more likely to have been accurately identified.

3.2.9 Funding for Implementation of Riparian Projects Appears to be Acceptable, but Funding, Treatments, Management, Monitoring and Maintenance Lack Continuity. Monitoring and Maintenance are Under-Funded; No Process Exists to Compensate for This. Emphasis is Incorrectly Placed on the Quantity of Projects Implemented Rather than their Quality or Long-Term Effect on Riparian Conditions.

These problems are explained by the organizational activities of the USFS (see 3.2.7) and the lack of personnel committed to the long-term recovery of riparian areas.

3.2.10 Baseline Inventories Documenting the Potential and Existing States of Riparian Areas are Inadequate. Improper Assessment of Site Potential Leads to Improper Treatment Selection.

Successful inventories of riparian area conditions require highly specialized analyses. The appropriate approach to treatment can only be developed after detailed analysis of the local climate, geology, geomorphology, hydrology, soils, and biota. The flow of water and sediment link riparian areas to their landscapes and are also important considerations when defining the existing riparian state. These and numerous other considerations are essential for proper assessment of site potential and treatment selection.

3.2.11 Few Projects Determine the Range of Project Alternatives or Define the Possible Consequences of Actions.

The purpose of developing and evaluating alternatives is to ensure that the problem is being addressed and that the goals and objectives will be met successfully in a comprehensive, effective manner. None of the project treatments were selected from a range of alternatives. Most were implemented with no assessment of existing conditions, no attempt to characterize the potential, and no planning For the projects to have succeeded, the project team would have needed to consider a full range of alternatives.

If necessary, outside expertise would have been called in to provide an interdisciplinary perspective, the necessary action would have been determined, and an approach to achieve the desired condition of the riparian area would have been attained through the implementation of the most appropriate alternative.

3.2.12 Project Maintenance was Overlooked in Most Projects and is a Major Cause of Treatment Failure.

Our project team found most projects failed to include proper maintenance. **No District produced a maintenance plan nor displayed how monies are budgeted to accomplish maintenance.** Many projects, such as the South Fork Bonito Creek, Houston Draw, and Little (East Fork) Colorado, were in total disrepair from lack of maintenance. One project, Arroyo Grande, although under-designed, was being maintained properly. However, as sediment reservoirs fill, annual maintenance costs will increase dramatically. Our team found no evidence of planning to prepare for future high costs. The Region should put a mechanism in place to plan for budget maintenance. Targets should be assigned to maintenance to reduce failures.

The most damaging non-maintenance factor was failure to maintain fences. Site after site was damaged by trespassing cattle because Districts were not maintaining project fences. A lesser, but still important problem, was a failure to maintain in-channel structures. The Rio de las Vacas and Comanche Creek rehabilitation projects are prime examples of good intentions gone sour because of a lack of maintenance. Almost all of the thousands of in-stream trash catcher structures placed by the USFS in the 1960s and 1970s had failed. Most of this failure rate can be attributed to insufficient design and lack of maintenance. Poor location is also a factor. The contrast between the lack of maintenance at the Windsor Creek in-channel structures and the high level of maintenance at nearby Holy Ghost Creek is a prime example of how easily projects can fail without proper maintenance.

3.2.13 Management Does Not Demand Success in Riparian Projects. This has Lead to Projects Being Undertaken by Personnel with insufficient Training and Expertise.

Successful riparian improvement projects require a thorough knowledge of riparian area dynamics including open channel hydraulics, sediment transport, alluvial channel dynamics, riparian vegetation habitat and reproduction requirements, and how land use practices can affect all of the above. In general, there is a lack of appreciation of the levels of expertise and careful planning needed to assure that riparian restoration efforts are successful. Management should demand success, be accountable for failures, and assure that project personnel have the expertise to get the job done right.

4.0 RECOMMENDATIONS

1. Adopt and implement watershed and riparian enhancement projects that recognize and integrate watershed condition and riparian health.

2. Assess all watershed management activities in relation to their effects on riparian conditions.

3. Define the level of expertise required to plan and implement projects. Make certain that qualified personnel are available to meet increasing demand by examining staffing levels and providing training and certification programs.

4. Use fire or mechanical techniques to improve riparian area condition **only** after planning and thorough analysis.

5. Apply minimum monitoring standards to every watershed and riparian treatment project.

6. Develop and implement monitoring as part of every project. At a minimum, a monitoring plan should address objectives, limiting factors and/or critical riparian components, monitoring techniques, frequency and duration, data analysis, interpretation, evaluation and presentation, and decision threshold levels.

7. Establish performance criteria for monitoring progress and state them explicitly in the monitoring plan.

8. Document all phases of riparian projects.

9. Assure that the USFS does not lose control of projects and allow volunteers and special interest groups to dictate project goals and objectives, treatment design, or implementation and maintenance schedules. Uphold quality construction and maintenance.

10. Establish guidelines that can be adopted by any administrative personnel.

11. Follow these guidelines for implementing structural solutions to watershed and riparian restoration projects;

    - Allow enough time for planning and design.
    - Recognize that the potential benefits from nonstructural solutions usually outweigh the benefits provided by structures.

- Recognize that cross-channel structures have limited utility.
- Improve guidance documents on fish-structure assessment, design, and maintenance.
- Design structures with the least-negative impacts using a bio-engineering approach.
- Do not place hard structures in soft banks.
- Do not under-design instream structures.
- Place structures in locations appropriate to stream dynamics.
- Do not ignore formal engineering designs because this may cause failures and hazards downstream.

12. Program funding for analysis, planning, monitoring, and maintenance into the overall cost of all projects.

13. Prepare a cost/benefit analysis for all projects and related land management activities.

- Apply proper treatment to each site. Avoid cookbook approaches.
- Improve baseline inventories of potential and existing states.
- Take into account water/sediment balances.
- Use a true interdisciplinary approach to designing riparian projects. Fully implement the IRM process for riparian projects.
- Apply treatments to appropriate areas in the right sequence.
- Do not ignore the potential of natural communities.
- Identify treatment potential.
- Implement risk analysis procedures.

14. Develop and approve a maintenance plan as part of project planning and incorporate this into the project action plan.

15. Do not approve or implement a rehabilitation project until a maintenance plan and budget is approved.

16. Many projects have failed because of the USFS' policy of rewarding project development and not rewarding project maintenance. Personnel interviewed were pressured to complete projects but were discouraged from maintaining existing projects.

17. Include a budget for project maintenance as part of the annual Regional, Forest, and District budget planning and implementation process.

18. Intermittently link project monitoring and maintenance plans. Adjust maintenance plans according to the monitoring results.

19. Develop and implement grazing strategies that promote the health of watershed and riparian environments.

20. Develop specific utilization standards and incorporate them into all grazing allotment management plans.

21. Do not fund riparian structural treatments until an environmental analysis can be performed. The analysis should demonstrate clearly that all possible improvement measures have been implemented.

22. Develop regional construction standards for riparian pasture and exclosure fences.

23. Increase the size of enclosures and exclosures.

5.0 GUIDELINES: DESIGNING RESTORATION PROJECTS

The diversity within watershed and riparian ecosystems precludes a "boilerplate" approach to restoration and the development of treatment plans. Methods that are effective in one ecological setting may not be applicable to another, and different goals may necessitate alternative designs for the same ecological setting. Some general guidelines for the design of treatment plans are:

Preliminary planning to identify the problem, scope, goals and objectives, approach, feasibility, conflicts, and disciplinary needs for restoration.

Baseline inventories to characterize the potential and existing states of the watershed and riparian area. These are necessary to evaluate the feasibility of preliminary objectives, refine the approach to restoration, provide input for the project design, and serve as a basis for comparison with monitoring data.

Evaluation of alternatives for accomplishing the goals and objectives.

Design to reflect objectives and limitations inherent to the project location, as documented in the baseline inventory. The design must accommodate available funding, specify evaluation criteria, and outline the action plan. Where construction is required, detailed drawings and maps should be included.

Implementation of the project.

Inspection of the project to correct or accommodate inconsistencies in the project design.

Monitoring of parameters to assess goals and objectives of restoration.

Maintenance to insure long-term success.

Each of these elements is discussed in the following sections.

5.1 PRELIMINARY PLANNING

During the preliminary planning phase of a restoration project, five evaluation criteria (defined in Section 2.0) should be addressed:

1. Problem identified and addressed.
2. Goals and objectives.
3. Assess feasibility of approach.
4. Conflicts with other values and land uses resolved.

5. Interdisciplinary/interagency coordination.

The USFS has increased its effort over the past decade to rehabilitate watersheds and streams under its jurisdiction. Successes and failures are as varied as the locations and the type of habitat in which the projects were established.

One of our major findings was that little effective planning was carried out before restoration took place. This problem is commonplace throughout the nation (Platts and Phillips 1990, Platts and Rinne 1985), despite pleas for thorough planning by numerous authors (Reeves and Roelofs 1982, Hall and Baker 1982, Everest and Sedell 1984, Klingeman 1984, and Platts and Rinne 1985). This is a serious problem because recent budgets for stream habitat improvement programs far exceed expenditures for planning and monitoring the rehabilitation of basic soil and watershed resources (Frissell and Nawa in press).

For appropriate plans to be prepared, sufficient information must be available during the alternative selection and final decision-making process. Generally, the treatment plans we evaluated in Region 3 did not have the benefit of this consideration. Most were unable even to identify watershed and habitat deficiencies.

A treatment plan should:

1. Identify the type of surveys needed, i.e., stream, lake, watershed.
2. Determine watershed conditions.
3. Coordinate with other appropriate land and water managing agencies.
4. Plan for monitoring.
5. Set goals and objectives.
6. Take the historical perspective into account.
7. Determine limiting factors and arrange them in order of influence.
8. Develop cost-benefit and feasibility analyses.
9. Identify the prescription to increase abundance of target species or improvement in habitat condition.
10. Analyze both physical and biological processes evident at sites.
11. Develop a classification system to ensure treatments are appropriate for the site.
12. Develop planning detail to simplify final decision-making.

13. Include stream and riparian habitat standards and criteria from Forest Plans in each project.

14. Prepare an organizational schedule.

The major elements of planning that need improvement are limiting factor analysis, classification, feasibility, alternative selection, evaluation, monitoring, and problem identification. Each of these elements are discussed in the following section.

Limiting Factor Analysis

Seldom does a single factor limit a species or watershed condition. One limiting factor may be dominant but, usually, multiple limiting factors control biotic populations and physical conditions. Limiting factors may not operate in concert and often change priority over time (Platts Pers. Comm. 1990).

None of the watershed or stream rehabilitation projects we evaluated included a limiting factor analysis during the planning stage or even after the project was completed. In many cases, the true limiting factor was not addressed in the rehabilitative treatments applied.

Limiting factor analyses should define:

1. The target species.

2. Critical life stages.

3. Current population levels or conditions.

4. Desired and attainable population levels or conditions.

5. Dominant and sub-dominant limiting factors by time period.

6. Relative contribution to population decline or condition degradation by each limiting factor during each life stage or period.

Classification

The planning of watershed or stream rehabilitation projects will be more effective if a hierarchial land classification system is used in the analysis (Lotspeich and Platts 1982). Classification is the most efficient way to place any rehabilitation effort into a basin-wide perspective (Figure 5-1). As was the case with limiting factor analysis, we found that none of the projects incorporated this or any other land classification analysis. As a result, the experience and understanding gained from other projects could not be used to guide planning efforts.

The success of a rehabilitation project is not simply a function of design but depends on the total physical and biological context of the basin (Frissell and Nawa in press). Classification is a tool to analyze complex factors.

Alternative Selection

Planning the selection of alternatives is often difficult because there are so many from which to choose. In most of the projects, a good range of alternatives was not considered. However, if this had been part of the planning process, it is likely that fewer treatment plans would have been based on structural approaches. Apparently, Region 3 has modified its IRM process to overcome this problem.

Evaluation

Rehabilitation activities should be evaluated to determine whether they are compatible with the affected area and whether they will meet the overall goals and objectives. This information can then be applied to future projects. An example of a test evaluation would be to ask whether the project increased the carrying capacity for trout and, if so, why? None of the projects we reviewed were evaluated adequately from this perspective. A few projects supposedly included some evaluation (i.e., Blue Water and Canyon Creek), but no District could provide us with an evaluation to review.

Monitoring

A monitoring program is an integral part of project planning because it provides an ongoing assessment of success or failure and identifies the maintenance necessary to protect the investment. Waiting until a project is completed before implementing a monitoring plan defeats the purpose of monitoring. Most project plans did not include a monitoring plan, nor was there any intention to include one. There were, however, a few exceptions (e.g., Canyon Creek).

5.2 BASELINE INVENTORY

USFS managers in the Southwestern Region face two urgent needs. The first is for a regional classification system to identify watershed and riparian areas of distinctive form, function, and ecological potential. The second is for consistent techniques to assess the existing condition of an area relative to its potential. Managers are presented with a valuable resource they know very little about and, as a result, restoration projects proceed haphazardly. Treatments applied to symptoms do not remedy the problem. Project designs often ignore or misinterpret the ecological potential of a site. No method has been developed to identify watershed and riparian areas that will respond to consistent restoration techniques.

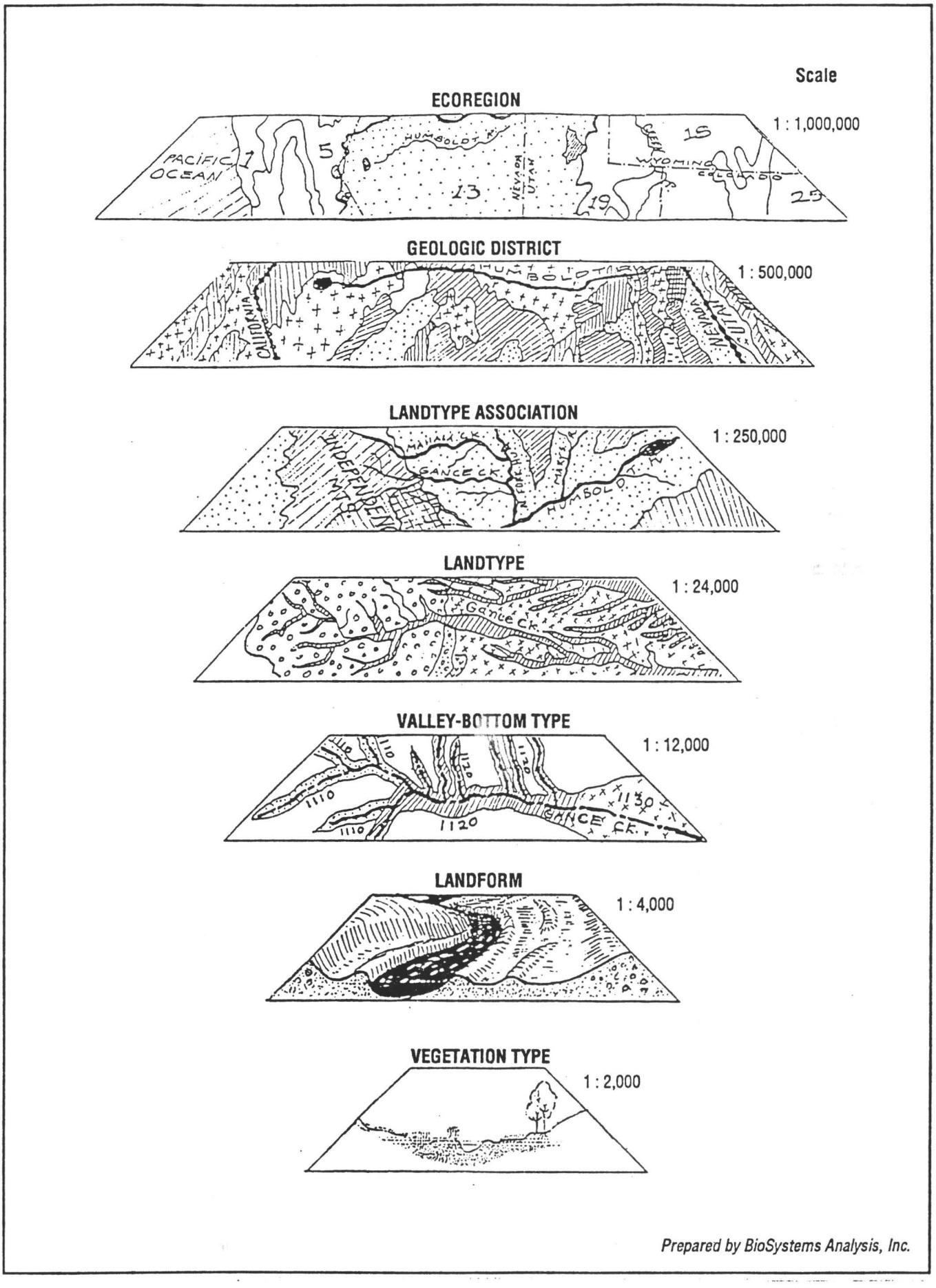

Figure 5-1. Map levels for hierarchical classification.

A baseline inventory includes classification, inventory, and assessment, all of which are essential for refining the preliminary planning and design of restoration projects. The baseline inventory can also serve as a basis for comparison with monitoring data.

A hierarchical classification system based on evolutionary processes can be used to identify watershed and riparian areas of distinctive ecological potential. Measurements of stream, channel, and riparian attributes can be used to assess the existing condition and these can then be compared to the ecological potential. Inventory entails compilation of maps and data summaries from different disciplines. Ideally, mapping of watershed and riparian areas should be conducted by the Region or National Forest. Restoration needs could be prioritized and baseline inventories for discrete restoration sites could be viewed from a broader perspective. A regional inventory would also facilitate comparisons of rehabilitation techniques.

At the very least, baseline inventories should be conducted for the drainage basin upstream from the site. Degraded conditions higher in the drainage may limit restoration in lower sites. To our knowledge, a hierarchical classification system for identifying relevant sites has not been developed for the Southwest Region, although most of the components of such a classification system are available. Given that only 7 of 29 restoration projects adequately evaluated site potential, a classification tool is warranted.

The approach to restoration must be flexible given the inherent diversity in watershed and riparian areas, the myriad of land and water uses that have affected it to varying degrees, and the many values applied to its management. An understanding of the geographical variables that determine the distribution of watershed and riparian areas with distinctive functional characteristics would be useful for formulating approaches to restoration. This would allow identification of watershed and riparian areas that will benefit from similar techniques and research findings.

In the following section, we discuss the factors that determine the potential of stream riparian habitat and a hierarchical approach to classification of watershed and riparian areas. This is followed by a conceptual discussion of the conditions within watershed and riparian areas of distinctive ecological potential and how to identify them.

5.2.1 Characterize Potential

The characteristics of watershed and riparian areas are related to local climate, geology, geomorphology, hydrology, soils, and biota. Some researchers believe that the characteristics of these areas are a response to the local climate and landscape while others argue that landscapes are an evolutionary response to the streams that they contain. The recommended approach to classification assumes that watershed and riparian areas and the landscapes in which they occur are a co-evolutionary response to the same processes.

The flow of water and sediment is the most apparent functional mechanism linking watershed and riparian areas to their landscapes. The balance between precipitation and evaporation determines the amount of water entering basins, which, in turn, influences stream flow and groundwater. Mountain formation determines the gradient of runoff, while weathering produces sediment. Glacial, fluvial, alluvial, colluvial, and lacustrine sediment transport result in distinctive types of watershed and riparian areas that may respond differently to similar restoration efforts. Within an area of distinctive geomorphology (e.g., glaciated land), differences in hydrology are usually evident along the slope of watersheds (e.g., glacial basins, glacial trains, and glacial outwashes). Soils also vary for different landforms (e.g., floodplain, levee, alluvial fan, moraine, channel) and vegetation types respond to soil and water regimes. While all watershed and riparian areas transport water and sediments along the slope of watersheds, the manner in which this occurs varies in response to climatic, geologic, geomorphic, soil, and biotic variables. Given that one purpose of restoration is to enhance the functional values and beneficial uses, it is important to recognize the geographical variables.

The diversity within a watershed and riparian ecosystem is apparent from several points of view, ranging from regional to site-specific. A hierarchical format can be used to stratify watershed and riparian areas into successively more homogeneous classes, identified by the causal factors influencing their functional characteristics. Bailey (1983, 1985) suggested that such a hierarchical format can be used to recognize several levels of nested ecosystems. At a broad level, ecosystems are identified by regional climatic and structural variables that provide the impetus to drive smaller ecosystems, identified by geologic and geomorphic variables, which influence still smaller ecosystems identified by biotic attributes. Processes that were not apparent at broader levels become evident at successively more refined scales. Differences in the functional characteristics of a watershed and riparian area will affect the potential, approach, and time required for successful restoration.

Some hierarchical classes used to identify watershed and riparian areas of more-or-less homogeneous qualities at successively more refined scales are shown in Table 5.1. Classes of the top levels are based on regional criteria from small scale maps and general information sources. Classes of the lower levels are based on more specific criteria from large scale maps and more quantitative information.

These hierarchical classes may be viewed as layers of information (see Figure 5-2). The top layers consist of large polygons (i.e., areas) described in terms of general criteria. At successively lower levels, these polygons are divided into smaller areas described in terms of more refined criteria, from which increasingly specific interpretations can be drawn. Classification is applied from the top level down, thus accounting for variance at the broadest level possible. The various scales used in the classification allow interpretation and generalizations ranging from regional to site specific. Site specific information for lower levels (e.g., success or failure of restoration techniques) can also be integrated to

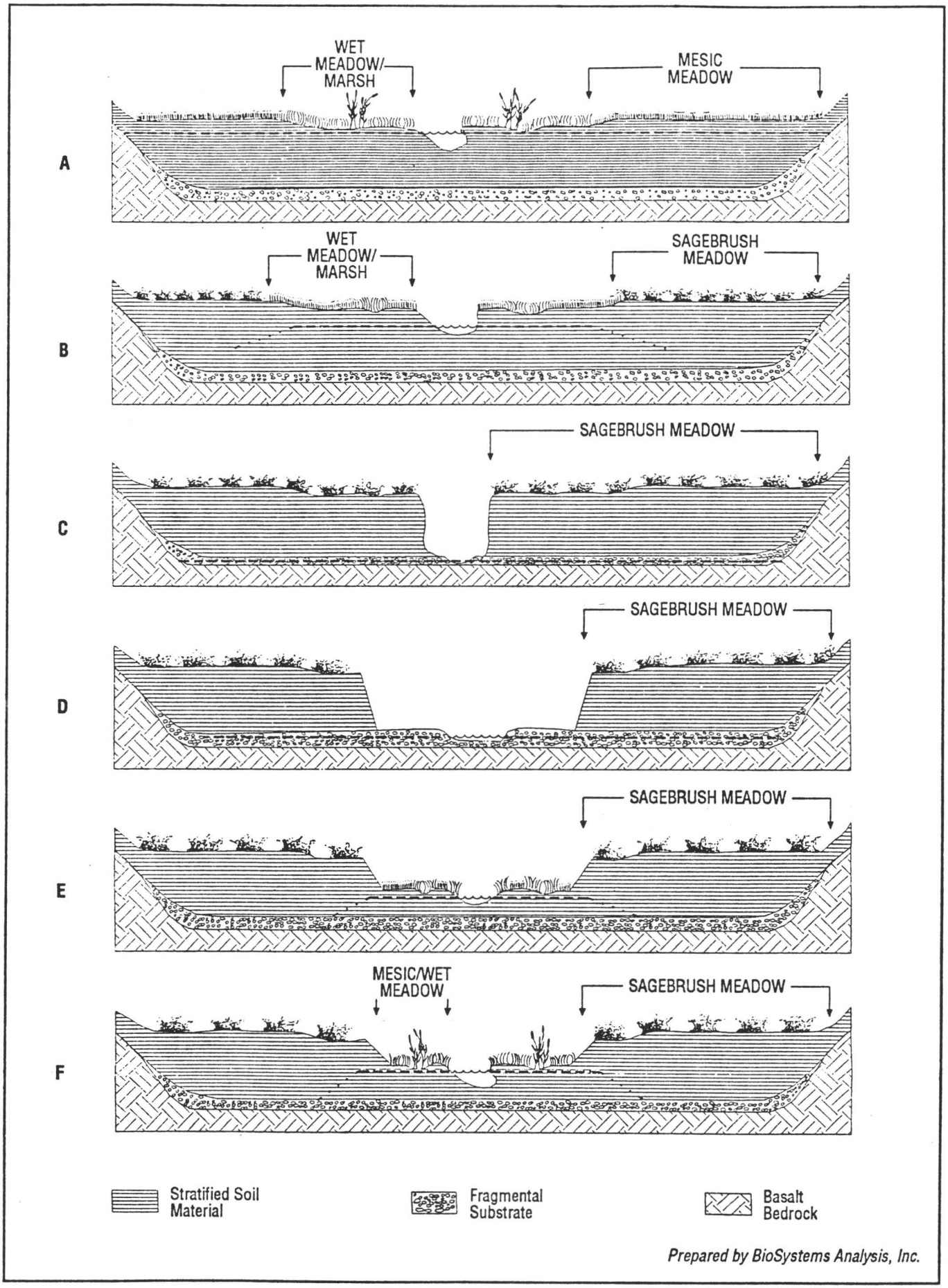

Figure 5-2. Example progression of states leading to an incised channel.

Table 5.1 Hierarchical levels of classification.

Ecoregion:	An area determined by similar land-surface form, potential natural vegetation, land-use and soil (Omernik 1987); they may contain few to many geologic districts.
Geologic District:	A portion of an ecoregion with relatively homogeneous parent materials, distinguished from surrounding districts by structure, degree of weathering, dominant size-fractions of weathering products and water-handling characteristics (e.g., porosity, permeability, runoff potential); includes both uplands and bottomlands; it may contain one to several landtype associations.
Landtype Association:	Some part (or all) of a geologic district that is distinguished by a dominant geomorphic mechanism (e.g., glacial, fluvial, alluvial, lacustrine); includes both uplands and bottomlands; it contains several landtypes.
Landtype:	A portion of a landtype association distinguished by form and position; it corresponds with associations of soils and plant communities; watershed and riparian areas is contained within the **valley bottom landtype**, which may include few to several valley-bottom types.
Valley-Bottom Type:	A subset of the valley-bottom landtype distinguished by form, structure and the manner in which water and sediment move through the system; they are generally distributed in a predictable manner along the elevational gradient of watersheds; it contains several to many landforms.
Landform:	A portion of the valley-bottom type with distinctive morphology (e.g., channel, floodplain, levee, alluvial fan); although the same landform can occur in several classes of broader hierarchical categories, its attributes must be assessed in the context of the geologic district, landtype association, and valley- bottom class in which it occurs; each landform may include one to several vegetation types.
Vegetation Type:	A distinctive biological condition identified by physiognomic class (i.e., forested, shrub, herbaceous, and substrate), water regime (e.g., seasonally flooded) and dominant plant species in overstory and understory canopies; it may change in response to land use.

support interpretations for higher levels. Broad classes (i.e., ecoregions, geologi districts, landtype associations and valley-bottom types) which normally do not change from one type to another in response to land-use can be used to identify watershed and riparian areas of *distinctive potential*. Refined classes (landforms and vegetation types) may change in response to land-use and reflect the *existing state* of watershed and riparian areas.

5.2.2 Characterize Existing Condition

The previously described hierarchical classification system can be used to assess watershed and riparian areas. Valley-bottom types are areas with distinctive form, function, and ecological potential. Measurement of stream, channel and riparian attributes can be used to identify the existing conditions of watershed and riparian areas within a valley-bottom type. These existing conditions can be arranged as a progression of states, ranging from near natural to severely impacted. For a given type of impact (e.g., cattle grazing), different valley-bottom types may respond through a different progression of conditions or through the same progression but at different rates or to different degrees. Assessments should determine existing states for valley-bottom types not only for a particular site, but also for the drainage basin of the site. The distribution and causes for existing conditions, and projections of the achievable condition should be evaluated.

Given that it requires restoration, the existing condition is probably different from the "natural or achievable" condition for a site. It is often the case that the "natural" condition of watershed and riparian areas is coincidental with maximum beneficial uses and, thus, may be the ultimate (though probably optimistic) goal of restoration. Given the extent of man's influence upon the environment, it is questionable whether natural conditions can be identified other than as a theoretical beginning. The achievable condition for a site is what can be expected as the end-point of restoration. To project achievable conditions, it may be necessary to locate minimally-impacted reference sites of similar ecological character to the project location. Selection of reference sites should entail evaluation of climatic, geologic, geomorphic, topographic, hydrologic, soil, and biotic attributes of both the project-site and potential reference sites.

Perhaps the most sensitive attributes for assessing the condition of watershed and riparian areas are within the stream channel. Stream bank, channel, and water column characteristics are often most susceptible to impacts. Impacts in the stream channel lead to deterioration of riparian habitat through alteration of groundwater geometry and flooding. Attributes that were found to be sensitive for assessing livestock impacts to watershed and riparian areas (Jensen et al. 1989) include:

- Banks eroded (percentage).
- Bank angle (degrees).

- Bank undercut (feet).
- Bank water depth (feet).
- Bank stability (rating).
- Depth of channel (feet).
- Channel width/depth.
- Stream width/depth.
- Channel width/stream width.
- Cross-sectional area channel/cross-sectional area of stream.

Methods for measuring these attributes have been described by Platts et al. (1987). Attributes are measured along replicate cross-channel transects. Measurements must take into account valley-bottom type and "bank-forming" landforms. Attributes differ where alluvial fans abut a channel and where floodplains or levees are bank-forming. Comparison of channel attributes measured in areas of the same valley-bottom type, but in conditions ranging from near natural to severely impacted, were used to develop concepts for a progression of conditions.

A progression of conditions leading to an incised channel is illustrated in Figure 5-3. This progression might be applicable to a V-shaped depositional canyon in the fluvial landtype association and sedimentary geologic district. Stream substrates are deep and erodible.

The natural condition (A in Figure 5-3) is characterized by hydric bank-forming vegetation, stable overhanging stream banks, a "fit" channel that overflows to dissipate the power of peak runoff over floodplains and levees, and ground water level within the rooting depth of riparian vegetation on floodplains.

Initial impacts of livestock grazing (B) include stream bank erosion, replacement of hydric bank-forming vegetation with streambars and more mesic vegetation types, and subtle lowering of stream and associated groundwater levels that allows encroachment of upland vegetation onto floodplains. These alterations represent a critical state, beyond which impacts lead to incision of the stream channel.

Incised channels (C) exhibit an increase in channel depth and width, significant lowering of stream and alluvial groundwater level, unstable banks, and replacement of riparian vegetation by upland plants. The higher and drier stream banks are more prone to failure, leading to broadening of the stream channel (D).

Given rest, vegetation stabilizes the wetted channel bottom, encouraging deposition of sediments and a rise in stream and groundwater levels (E). Continued aggradation and stabilization eventually leads to an achievable condition (F) that is similar to the natural condition, although usually at a lower base-level. Harvey and Watson (1986) describe a similar evolution of conditions for all incised channels.

The critical condition (B) is that beyond which impacts lead to permanent loss of riparian habitat. Once incised, it is unlikely that streams can be brought back to their original grade. If the resource is to be preserved, management and restoration must address this critical condition. In practice, we found that the focus of restoration efforts in the Southwestern Region were more degraded conditions (C and D). While restoration of the critical state (B) to a near natural condition can usually be accomplished easily over a relatively short time, restoration of more deteriorated conditions requires expensive applications over longer times and only result in a diminished version of the natural potential. Net benefits per dollar invested may be ten to twenty times greater if applied to the critical condition, before incision.

Other valley-bottom types with erodible substrate may follow a similar progression of conditions, but the susceptibility to impact under the same intensity of use, or the rate at which restoration proceeds, given elimination of impacts, may be very different.

Documentation of the existing condition relative to a progression of conditions can be used to evaluate the potential for restoration and can serve as a baseline for evaluating the success of restoration. Impacts causing deterioration should be identified. Baseline inventories may also include documentation of fish and wildlife populations.

5.2.3 Other Baseline Assessments

In addition to previous baseline determinations of potential and existing conditions, other assessments may be required to evaluate preliminary planning, select alternatives, or as input to the project design. These might include soil, vegetation, hydrology, fishery, and wildlife surveys.

Soil Surveys: Soil surveys are used to determine the volume of materials available for use in restoration and may be needed when contouring is envisioned. The intensity of the survey must be commensurate with the scope and approach to restoration. Where extensive earthwork is envisioned, an order 1 (very detailed) soil survey should be conducted. Soil types (polypedons) are delineated on aerial photos. Representative profiles of each soil type are described and classified (Soil Conservation Service 1975). Samples of each soil horizon are obtained for physical and chemical analyses to identify limiting characteristics for use in restoration. Soil properties important for use in restoration are summarized in a document prepared by the U.S. Army Corps of Engineers (Environmental Laboratory 1986). More general (order 3-5) soil survey

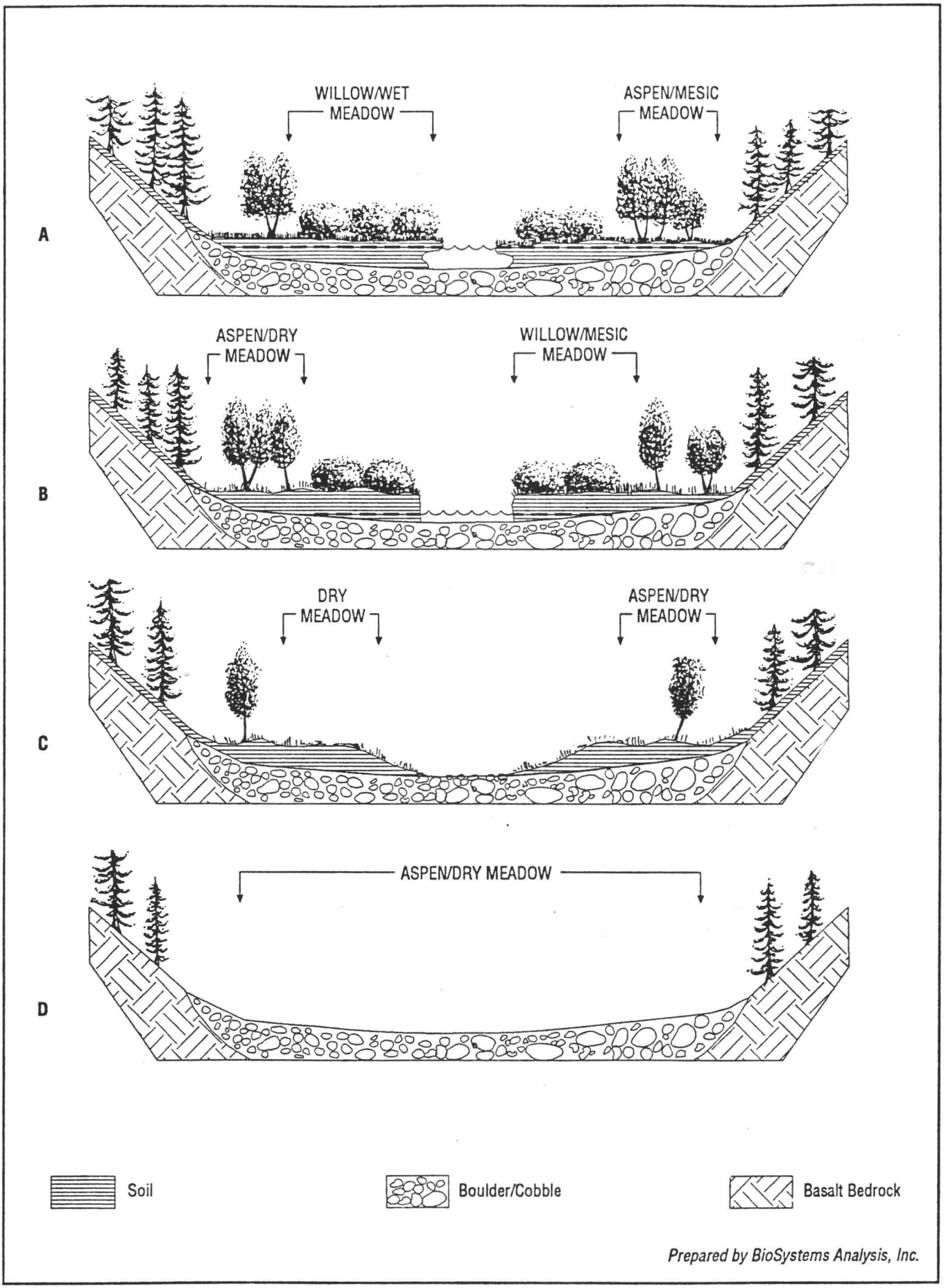

Figure 5-3. Example progression of states leading to an overbroadened channel.

reports published by the Soil Conservation Service may be adequate for projects not requiring earthwork.

Botanical Surveys: These can be conducted in conjunction with the soil survey. Plant communities are delineated on aerial photographs. Species composition and cover are described for representative communities of each type. Environmental attributes (e.g., landform, soils, frequency and duration of flooding) are also described. Threatened, endangered, and sensitive plant species must be identified. Botanical information can be used to formulate vegetation designs and to determine what plant materials useful for restoration are available at the project location. Where available, classifications of riparian community types should be used.

Fish and Wildlife Surveys: The goals of restoration are often to enhance fish and wildlife resources. Fish and wildlife surveys can be used to identify species of concern and to provide baseline information against which monitoring can be compared. Inventories can also be used to estimate the potential of the site and to identify factors that affect carrying capacity. Surveys may include population estimates and/or assessment of habitat.

Populations can be estimated directly or indirectly (USFWS 1980). Direct methods entail counting individuals and are best suited to populations that are sedentary or concentrated in limited areas (e.g., fish in small streams). Indirect estimations of populations use indices (e.g., pellet counts) from which population sizes are estimated. Population estimates may be influenced by sampling errors, cyclical fluctuations, removal by sportsman, migration, etc. Reliable estimates of population potentials or carrying capacity may require several years of monitoring. Changes attributable to restoration may be difficult to distinguish from variability inherent in population dynamics.

Habitat: Habitat supplies the space, food, cover, and other requirements for the survival of a particular species. Much of the long-term variability in populations can be attributed to changes in the quality and quantity of their habitat. Assessment commonly includes measuring habitat indices (e.g., pool quality, canopy cover, plant composition and density, etc.) thought to be important to fish and wildlife species. Measures of habitat indices are compared with those of optimum habitat to assess condition for a particular species.

Habitat data can be used to provide information on the capability of sites to support specific species, management guilds, or even communities. Some of the habitat-based procedures that could be used are: Habitat Evaluation Procedures (HEP) (USFWS 1980), Stream Corridor Inventory and Evaluation System (SCIES) (Garcia, et al. 1984), Wetland Evaluation Technique (WET) (Adamus et al. 1987), and various regional wildlife-habitat relationships programs. Other procedures have been developed for evaluating fishery values. The Index of Biotic Integrity (IBI) was formulated to assess

fisheries from measures of species composition, trophic composition, fish abundance, and condition (Karr et al. 1986).

5.2.4 Baseline Report

Baseline information should be assembled as maps and reports. The format for information should allow sorting, summary, and evaluation. The baseline report is used to refine goals, objects, and the approach to restoration. This information provides input to the project design.

5.3 EVALUATE ALTERNATIVES

The purpose of developing and evaluating alternatives is to ensure that the problem is being addressed and that the goals and objectives will be successfully met in a comprehensive effective manner. Achieving success at this point in the process is dependent upon the project team considering a full range of alternatives and having sufficient expertise and information available to analyze how the desired condition of the riparian area can be attained through the implementation of a particular alternative.

In general, a high level of expertise is required at this point. Physical and biological processes are complex and dynamic in riparian systems. The project team must be able to accurately assess, or model, how this system will respond to a treatment throughout the year, over time, and through a variety of flow conditions, including extreme flows. Furthermore, project planners must accomplish this evaluation while fully taking into account the particular and often unique existing site conditions and site potential. Recognition of site potential, trends, and the physical processes at work in the system is crucial in developing alternatives that complement on-going processes. Ultimately, approaches that complement, guide, or direct the prevailing physical processes at work at a site will have a much greater chance of success than alternatives that attempt to work against them.

A third possible cause of failure in evaluating alternatives may be pressure within the agency to cultivate partnerships with special interest groups. While well-intentioned, such partnerships often result in a desire to "do something" in the stream or riparian area that is structural in nature and can take advantage of a volunteer work force. Succumbing to such pressure tends to preclude fully evaluating management-related treatments that tend to provide more long-lasting sustainable improvements in riparian area condition.

5.4 PROJECT DESIGN

Information pertinent to the project area should be assembled and its relevance and accuracy evaluated. While general information used for broad-scale assessments may be useful for determining a general approach to restoration, it is usually not sufficient for design of restoration projects. More accurate inventories and assessments are generally required. Designs commonly require the expertise of engineers, hydrologists, soil scientists, botanists and wildlife specialists.

Restoration can rarely be accomplished if impacts to the site are not controlled or eliminated. On-site impacts may be attributed to numerous factors and fencing and/or closure may be necessary to control these impacts. Off-site impacts may influence the site through upstream irrigation withdrawals, regulation of streamflow by upstream reservoirs, headcutting of stream channels, deposition of sediment from upstream sources, and alteration of runoff/retention relationships of contiguous uplands. Methods for dealing with off-site impacts must be addressed in the project design.

Details of the design plan will vary depending on the type of restoration envisioned. Following are some topics that may be applicable.

5.4.1 Topographic/Hydrologic Design

A topographic design should be provided if restoration entails alteration of the stream course or contouring. Contour maps and cross-section drawings can be used to illustrate layout and relief. The scale and contour interval should enable accurate projection of hydrologic variables such as water depth, extent of flooding, and depth to perched aquifers. Miller (1987) suggests a scale of 1:240 to 1:600 and a contour interval of 1-foot for design of freshwater wetlands, although 1:1,200 to 1:2,400 surveys with 5-foot contours are used more commonly. The scale and contour interval should be such that hydrologic variables can be accurately assessed.

A reliable source of water is crucial to successful restoration. Water sources might include streamflow, groundwater, spring discharge, and precipitation. Accurate projections of the dynamics of discharge, gradient, velocity, and stage are necessary for sizing stream channels and floodplains, for assessing risk to structures (e.g., check-dams), and for predicting erosion and stream bank stability. The effects of anchor ice must also be anticipated. Stream gauging stations monitored by the U.S. Geological Survey are usually the only source of long-term streamflow measurements. The use of computer models developed by the U.S. Army Corps of Engineers (HEC1 and HEC2) has been suggested for evaluation of basin hydrology, channel hydraulics, and equilibrium analysis for stream channel (Lidstone 1987). Instream Flow Incremental Methodology (IFIM) developed by the USFWS (Bartholow and Waddle 1986) can be used to evaluate the effects of basin-wide water allocations upon restoration potential.

The relationship between the stream level and alluvial groundwater level is important for designing grades to achieve the proper hydrologic conditions for riparian vegetation. This relationship is influenced by the depth and permeability of substrates and by valley-form. Monitoring wells (perforated plastic pipe inserted in bore-holes to a depth below the minimum groundwater level) can be used to measure spatial and temporal variations in alluvial groundwater level and its relationship to stream levels.

Successful restoration often hinges on the design and construction of a stream channel. Important perspectives are stream pattern, cross-section, and grade. Stream pattern is the configuration of a stream as seen from the air. Meanders usually occur in valleys with gentle slopes and with soils sufficiently cohesive to provide firm banks (Leopold and Langbein 1966). In these situations, the distance along which a river is straight is generally less than 10 times its width. Stream pattern is commonly expressed in terms of the "sinuosity ratio," defined as the length of the stream divided by the down-valley distance it traverses. A meandering stream pattern is probably the single most beneficial feature for creation of watershed and riparian areas for a relocated channel (Jensen et al. 1987; Vinson 1988). Construction costs are directly proportional to the sinuosity ratio.

The form of meanders is important in determining the rate at which banks are undercut and eroded. Stream banks tend to erode more at sharp bends than along gentle curves (Leopold et al. 1960). Since the elevations of a valley are fixed, the sinuosity of a stream is the most important factor influencing water velocity. Consideration of both stream pattern and grade is necessary to achieve acceptable stream velocities, relative to erosional restraints and optimal habitat parameters.

Materials and cross-sectional dimensions for construction of stream channels must take into consideration both channel capacity and the stability of streambeds and banks (Jackson and Van Haveren 1984). Cross-sections should conform to the dimensions of natural channels with similar hydrology. Computer models developed by the COE (HEC1 and HEC2) can be used to predict the recurrence interval of flow and the effect of flows upon bed and bank stability.

The design gradient for stream channels should be consistent with that upstream and downstream from the site (Rundquist et al. 1986). If a gradient is too shallow, headcutting of the downstream segments and aggradation of upstream segments may occur. Too high a gradient leads to the reverse. Where design gradients do not conform with those in the vicinity, grade control structures such as check dams may be required.

An appropriate restoration plan for many sites is one that allows an existing stream channel to evolve into a more stable and productive system. All incised channels tend to develop toward more stable conditions (Harvey et al. 1985). Stages of evolution include incision, headward migration, channel widening, channel slope reduction, reduction of bank angles, deposition of sediment, and establishment of vegetation. Restoration should

be designed to enhance the evolution of more stable conditions, not to short-cut the evolutionary stages. Restoration of incised channels generally includes control of grade, control of discharge, or a combination of both (Harvey and Watson 1986).

Off-site impacts may affect water resources and complicate restoration. Methods for control of off-site impacts should be addressed for worst-case scenarios. Both high and low flows impacts should be considered. Off-site impacts may also affect restoration by influencing sediment dynamics (e.g., headcutting of stream channels or deposition of sediment). Grade control structures may be required for these situations.

5.4.2 Soil Design

Soil resources should be identified and evaluated as part of a baseline inventory. When restoration requires contouring, a plan for handling soil/substrate materials should be required. The design plan should specify methods for stripping, stockpiling, and redistribution of soil-materials.

Several types of soil-material may be distinguished by qualities influencing their value for use in restoration. Topsoil can be used for establishing herbaceous vegetation on floodplains; gravelly-loam substrates are suitable for establishment of willows on channel levees; clean gravel can be used as channel substrate for spawning; sand can be placed along the edge of channels to allow a stream partial freedom to choose its own course; and boulders can serve as instream cover for fishes. The **mixing** of these materials renders each one useless. Segregating and stockpiling contrasting soil-materials with different values for use in restoration should be carefully evaluated in the light of project goals and cost restraints.

5.4.3 Revegetation Design

Revegetation designs should conform with topographic, hydrologic, and soil designs. Plans should identify the types of riparian communities to be established, the area and distribution of each type, the composition of each type, methods for propagation, and sources of propogules. Existing watershed and riparian areas representative of the achievable state for the site may serve as templates for revegetation design.

The beneficial use of restored watershed and riparian areas is affected not only by the area of riparian habitats, but also by their location. Tall shrubs and trees can be placed to shade stream channels for fish. Wetlands can serve as "moats" to restrict access to critical wildlife areas or to enhance the quality of wastewater effluents.

Selection of species for revegetation should consider project goals, location, climate, microclimate, tolerance, soil, plant growth habits, availability of propogules, maintenance requirements and costs (U.S. Army Corps of Engineers 1987). If the goal of a project is

to establish habitat for target wildlife species, any plant known to be of value for cover, food, resting, or nesting of those species should be considered. If stream bank stabilization is a goal, other species may be considered. Lists of wetland plants, their regional distribution, and wetland status (e.g., obligate hydrophyte, facultative hydrophyte, etc.) have been assembled for the Southwestern Region (Reed 1986). Whitlow and Harris (1979) and Allen and Klimas (1986) reviewed flood tolerance, values, and habitat requirements of plant species for different regions of the United States. Kadlec and Wentz (1979) and the Environmental Laboratory (1978) tabulated soil and moisture conditions, geographic regions, morphological characteristics, potential uses, and propagation techniques for numerous plant species.

Alan and Klimas (1986) suggest that the adaptations of pest plants (e.g., rapid dispersal, fast growth, and hardiness) such as canary grass are the very characteristics that favor their growth on new or bare substrates. Where pest plants are not already dominant in the area, their use in restoration should be avoided. Native wetland vegetation will probably be replaced by canary grass introduced during restoration of the Coleman Lake site.

Propagation must be selected based on site constraints, scheduling, species, and costs. Herbaceous vegetation can be established by seeding (broadcast, drill, hydroseeding, and aerial seeding) and transplanting (springs, rootstocks, rhizomes, and tubers). Trees and shrubs are propagated from cuttings, bare-root, or containerized stock. Alan and Klimas (1986) discussed methods, costs, and relative advantages of these techniques and suggest some special techniques applicable to unstable situations. Doer and Landin (1983) suggested 180 to 270 pure live seeds per square meter for drill seeding and double this rate for broadcast seeding. Natural colonization from surrounding wetlands often outpaces transplanting efforts. Preliminary evaluations of controlled flooding during critical periods when streams are transporting catkins of willow and birch are encouraging (Jensen et al. 1987). Controlled flooding can also be effective for diversifying the composition of the herbaceous stratum, but should be timed to preclude dissemination of weedy species.

5.4.4 Habitat Features

Designs should enhance specific values of restored watershed and riparian areas. Examples include the artificial bank covers and instream boulder placements used to enhance fish habitat in a relocated segment of Birch Creek (Vinson 1988). Perches and nesting platforms can be used to enhance habitat for birds. Instream structures can enhance fish habitat (Binns 1986). Rosgen and Fittante (1986) discuss selection of fish habitat structures suitable for specific stream types. Hubert (1986) assessed the longevity and costs associated with maintaining stream improvement structures.

Successful restoration is often dependent upon the control of on-site and off-site impacts. On-site impacts may include livestock grazing and recreation. Fences and/or signed closures may be required to facilitate or maintain restoration.

Schedule A schedule for completion of critical aspects of a design plan should be required. This schedule should conform to seasonal variations inherent to the site. For example, construction and stabilization of sites must often be completed within a single growing season to preclude serious impacts from spring runoff.

5.4.5 Funding

A *budget* for application, monitoring and maintenance of the restoration plan should be prepared. The projected benefits of restoration should be compared with the budget and cost/benefit evaluated.

5.4.6 Evaluation Criteria Defined

One of the most critical aspects of a monitoring program is defining the evaluation criteria. Monitoring or performance criteria need to be specified before the project's success can be evaluated. Monitoring criteria should be linked to management area goals and project objectives, and should be relatively easy to measure.

5.4.7 Project Action Plan Developed

An action plan should include: a summary of preliminary planning, including the problem, goals, objectives, feasibility assessment, conflict resolution, and interdisciplinary/ interagency coordination; a summary of the baseline inventory, including identification of the potential and existing states and characterization of key variables (e.g., hydrology) important to success of the project; summary of alternatives considered and the rationale for *why* a procedure was selected; maps, drawings, and descriptions of proposed actions indicating *who, what, where, when*, and *how* restoration will be accomplished. Materials and labor needed to accomplish the project and costs for proposed actions should be estimated.

A *monitoring plan* (see evaluation criteria 13) should be part of the project design. The plan should specify the criteria that will be used to evaluate the project. Criteria should be objective and measurable. Sampling methods, locations, frequency of sampling, and the period over which monitoring will be conducted should also be specified. Monitoring should be sufficiently detailed so that statistical tests of success/failure can be conducted. Costs for monitoring should be projected.

A *maintenance plan* should also be part of the project design. Responsibilities for maintenance of fences, structures, and other features important to the longevity of the

project should be specified. The frequency, scheduling, and period during which maintenance will be conducted should also be specified. Costs for maintenance should be projected.

5.5 QUALITY OF PROJECT IMPLEMENTATION AND INSPECTION

The purpose of inspection is to verify compliance with restoration designs and to evaluate construction according to project goals. Mid-course corrections may also be suggested. It is recommended that inspection personnel be identified before starting construction. Inspection personnel should have the authority to stop work when it is out of compliance. Inspection personnel, usually from regulatory agencies, are especially important in projects requiring workers who are responding to orders from a contractor who may not be constantly available on-site. Education of workers in the purpose and goals of the project may contribute to the success of restoration. Frequent inspections should be conducted during critical aspects of construction and less frequently once it is clear that construction is proceeding correctly.

Project implementation results in the actual construction of a treatment or instituting a change in management. Good implementation results in a project that is installed as designed (regardless of the quality of the design or the appropriateness of the selected treatment).

The key factors, however, are difficult to assess. The interest, commitment (pride in a job well-done), and level of expertise of the responsible individuals are probably the most important factors in the quality of on-the-ground implementation. Rigorous design, the interest/commitment of senior staff and line officers to a project, an appropriate level of staffing so project personnel can devote the time needed to ensure quality implementation, and a high level of control over the personnel performing the actual construction all enhance the chance of success of a project.

5.6 IMPLEMENT MAINTENANCE

Development of a project action plan must include a maintenance plan and identification of the necessary budget needed for maintenance. A maintenance plan, including a budget, should be incorporated into all project action plans. If maintenance is not part of the project planning process, the proposed project should be sent back for re-planning immediately. A project plan should determine the life expectancy of a proposed rehabilitation project to conduct a feasibility analysis. This analysis cannot be done accurately until the degree and success of maintenance is adequately estimated.

Line officers will make fewer errors with a proper maintenance program. Many projects will require more work after project completion than was necessary to complete the

construction phase of the project. Frissell and Nawa (in press) found artificial stream structures in Oregon and Washington suffered high rates of damage. Fourteen percent of structures surveyed failed within 5 to 10 years. Projects with lower rates of damage rated much higher. The probability of failure increases with a structure's age.

The day is fast approaching when all rehabilitation projects will have to demonstrate benefits gained for monies spent. Net benefits cannot be gained immediately after project completion, because benefits cannot be determined until the project has a track record.

5.7 MONITORING

Monitoring evaluates progress toward meeting management goals and objectives and determines maintenance needs. The complexity and intensity of monitoring will vary depending on the priority, potential, Forest Plan requirements, and management opportunities of a site. Specific variables used for monitoring should be derived from specific project objectives and acceptable performance goals set during project planning and design. Variables considered often address physical parameters and population measurements. Physical parameters may include: frequency and duration of flooding; groundwater dynamics; channel morphology; stream bank stability; streamflow characteristics; water quality; vegetative composition, cover and production; stream shading; etc. Population measurements may include determining fish and wildlife indexes (e.g., redd counts, species diversity or richness, bird call counts, etc.), or actual cohort enumeration estimates, and input from the using public. The type and intensity of monitoring is tailored to the particular project.

Monitoring is essential in natural resource management to determine if:

- A project was implemented correctly (inspection).
- Goals and objectives are being achieved.
- Maintenance is needed and when.
- A project is a success or failure and the reasons for success or failure.

Monitoring is an important feedback mechanism that provides a basis for adaptive resource management. Analysis, interpretation, and evaluation of monitoring results may suggest modifications to the design, management, goals and objectives, and the monitoring plan.

The degree, frequency, and timing of monitoring are important considerations determined by project goals and deadlines. Monitoring may be conducted frequently in

the beginning and less frequently after trends are determined. Frequent monitoring can be used to identify variables that limit restoration to support mid-course corrections. Once it is clear that restoration is proceeding at an acceptable rate, monitoring may be conducted less frequently. For example, projects are commonly monitored monthly while vegetation is becoming established and biannually thereafter. Observations also should be conducted during winter months. The duration of projects monitored should be sufficient to accomplish objectives.

A monitoring plan should be developed and implemented as part of a project action plan. The plan does not need to be long, but it should include the necessary components. At a minimum, a monitoring plan should include the following points: introduction, objectives, limiting factors and/or critical riparian components, monitoring techniques, personnel responsible for monitoring, frequency and duration, data analysis, interpretation, evaluation and presentation, and decision threshold levels (Mayers 1989). Criteria for success/failure should also be specified in terms of monitoring variables (e.g., bank stability, vegetation cover, or fish populations). A contingency plan should be specified if monitoring indicates that success criteria are not achieved by a specified date. The personnel or agencies who will review the monitoring reports should also be specified.

Minimum monitoring standards should be applied to every watershed and riparian treatment project implemented by the USFS. At the very least, these standards should consist of standardized, monumented photo-plots that are updated periodically and qualitatively analyzed and interpreted. All aspects of the monitoring plan and all results from monitoring must be documented and filed for retrieval. Adequate monitoring, like any other component of a watershed and riparian treatment project, requires a commitment of time and money. In the case of monitoring, this obligation needs to be long term and must bridge the gaps caused by personnel changes as well as prevail over specific short term administrative and planning targets.